DRIFT, PLATTEVILLE, AND ST. PETER AQUIFER

PUMPING WELL EVALUATIONS AND

CESSATION REQUEST

REILLY TAR & CHEMICAL CORP.

N.P.L. SITE

ST. LOUIS PARK, MINNESOTA

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Executive Summary

This report provides the technical basis for completing certain elements of the Reilly Site Consent Decree – Remedial Action Plan (CD-RAP). The specific remedial elements discussed are the groundwater pumping at wells W410, W420, W421, and W439 in the Drift, Platteville, and St. Peter Aquifers. In accordance with prior pumping cessation efforts, this report proposes numeric cessation criteria and evaluates the hydrogeologic setting in the aquifers. The timing for this cessation request is identified in Part BB of the Consent Decree that provides a milestone horizon of 30 years for completing various remedial elements. At this point in time there are approximately 1,850 PAH analyses spanning more than 24 years in the Drift, Platteville, and St. Peter Aquifers. This report will show that the overall trends in the data clearly support cessation of pumping in the non-drinking water aquifers.

Appendix A contains graphs showing the concentrations of total PAH over time for most of the wells that have been monitored for the CD-RAP. Also the entire water quality database for all Reilly Site groundwater monitoring results through October 2, 2012 is available. In summary the data indicate:

1. Total PAH concentrations were steady or decreasing in 53 of 58 Drift, Platteville, and St. Peter Aquifer wells monitored for the Reilly Site.
2. Individual PAH compositions in the source area and in downgradient areas are consistent with literature descriptions of biodegradation and natural attenuation of PAH compounds. PAH naturally have limited mobility in the environment, and the Reilly Site data bear this out.
3. Individual PAH concentrations meet current Minnesota Department of Health and U.S. Environmental Protection Agency drinking water criteria in a large portion of the site area. Shallow groundwater in the vicinity of the bog area contains PAH above the current criteria. A much larger area contains PAH above the CD-RAP drinking water criteria which are roughly 1000 times more stringent than current Minnesota Department of Health and US Environmental Protection Agency drinking water criteria for PAH. Background levels of PAH in normal urban runoff, which recharges the shallow aquifers, may be expected to exceed the CD-RAP drinking water criteria (see Section 3.1.1).

The objectives for each of the four pumping wells in the shallowest aquifers were to limit the spread of PAH or control the source. The City believes that for all practical purposes this goal has been met and the pumping wells can be turned off. The practical aspect of this belief is based on assessing groundwater using current drinking water standards and on the fact that restoring groundwater to PAH concentrations below the CD-RAP drinking water criteria was not part of the goal of the pumping wells. Groundwater monitoring after cessation will evaluate the effectiveness of this response action. Wells W410, W420, W421, and W439 will be maintained such that pumping could be resumed if unacceptable risks are found during post-cessation monitoring. Section 5 of this report formally requests cessation of pumping in these four wells.

The City has decided, as a matter of public policy independent from water quality monitoring results, that pumping in the Prairie du Chien – Jordan drinking water aquifer and treatment of that water with activated carbon for use in the public water supply system will continue beyond the 30-year milestone in the CD-RAP. Source and gradient control in the Prairie du Chien – Jordan Aquifer are not part of this cessation request.

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1.0 INTRODUCTION

1.1 Reilly Site Remedy Background

The operation of a coal-tar distillation and wood preserving plant in the City of St. Louis Park, Minnesota, (the Reilly Site) from 1917 to 1972 resulted in soil and groundwater that have been found to contain polynuclear aromatic hydrocarbons (PAH) as a result of Reilly's activities. Numerous studies have evaluated PAHs in various aquifers beneath St. Louis Park and adjacent communities. The studies led to a comprehensive cleanup plan for the Reilly Site embodied in the 1986 Consent Decree – Remedial Action Plan (CD-RAP). The United States Environmental Protection Agency and the Minnesota Pollution Control Agency (the Agencies), the Minnesota Department of Health (MDH), the City of St. Louis Park (City), and Vertellus Specialties Inc. (formerly Reilly Tar & Chemical Corporation) are parties to the CD-RAP. The introduction of the 1986 CD-RAP addresses the following goals for the Reilly Site:

1. Provide a safe drinking water supply in sufficient quantity for the City of St. Louis Park and surrounding communities;
2. Control the spread of Contamination (as defined by the CD-RAP) in the Drift-Platteville, St. Peter, Prairie du Chien - Jordan, Ironton – Galesville, and Mt. Simon – Hinckley aquifers resulting from activities at the Site;
3. Allow for the safe, reasonable, and beneficial use of the Site and adjacent Contaminated areas; and
4. Preserve and protect groundwater resources for present and future use.

The first CD-RAP goal was achieved by providing granular activated carbon (GAC) treatment systems for the municipal water supplied by City wells SLP4, SLP10 and SLP15. The drinking water criteria established in the CD-RAP (Section 2.2) include the following concentration levels (in units of nanograms per liter [ng/l] or parts per trillion):

CD-RAP Drinking Water Criteria

	Advisory Level	Drinking Water Criteria
Sum of benzo(a)pyrene and dibenz(a,h) anthracene	3.0 ng/l*	5.6 ng/l
Carcinogenic PAH	15 ng/l	28 ng/l
Other PAH	175 ng/l	280 ng/l
***** or the lowest concentration that can be quantified, whichever is greater		

The third CD-RAP goal was achieved by covering the site with soil to create a surface barrier between people and PAH in soil. The CD-RAP (Section 11.5.3) requires the Agencies to review and approve construction plans any time a redevelopment project occurs at the Reilly Site. Other institutional controls, such as deed restrictions, have also been implemented at the Site. The site has been 100% redeveloped for various residential, commercial, and recreational uses and the City continues to monitor the surface barrier for adequate cover.

The second and fourth CD-RAP goals are inter-related and are the subject of this report. The CD-RAP required implementation of remedial measures to limit the spread of PAH in the Drift, Platteville, St. Peter, Prairie du Chien – Jordan, and Ironton – Galesville Aquifers. The method specified by the CD-RAP for limiting the spread of PAH in groundwater was the use of pumping wells. Cessation criteria were specified in the CD-RAP for the wells in the Prairie du Chien – Jordan and Ironton – Galesville Aquifers, but not for the Drift, Platteville, or St. Peter Aquifers. This report proposes cessation criteria that have already been achieved in the Drift, Platteville and St. Peter Aquifers and recommends cessation of pumping in those aquifers. Cessation of pumping will allow the City and the Agencies to accomplish the following goals:

1. Complete specific remedial elements as discussed in Part BB of the CD-RAP, and
2. Conserve resources associated with pumping and dumping groundwater.

1.2 Pumping History

The CD-RAP (in Sections 4, 6, 7, 8, and 9) relies on groundwater pumping to control PAH and required pumping in all aquifers affected by contamination from the Reilly Site. **Table 1** provides a summary of the pumping wells used to limit the spread of PAH at the Reilly Site. **Figure 1** shows the locations of pumping and monitoring wells in the Drift, Platteville, and St. Peter Aquifers. **Figure 2** locates wells in the Prairie du Chien – Jordan and deeper aquifers. Wells W105, W422, and W434 were pumping wells that have already been turned off. Wells W410, W420, W421, and W439 pump an average of approximately 200 gallons per minute from the St. Peter, Platteville, and Drift Aquifers at an annual cost to the City of approximately \$250,000. These four wells are candidates for cessation and are the subject of this report. The Prairie du Chien – Jordan Aquifer pumping wells are also municipal supply wells that are treated and used for drinking water. No cessation of pumping is proposed for the Prairie du Chien – Jordan Aquifer.

The history of pumping in each aquifer is described below. No pumping was required in the Mt. Simon – Hinckley Aquifer.

As shown in **Table 1**, Ironton - Galesville Aquifer well W105 met the quantitative cessation criterion established in the CD-RAP 9Section 6.1.5), namely water quality results less than 10 micrograms per liter, and pumping stopped in 1991 after five years of operation. Water quality results greater than 10 micrograms per liter in 1992, 2008, and 2010 are believed to be related to inadequate well purging rather than an actual increase of PAH in the Ironton Galesville Aquifer. Additional samples collected after the elevated results verified that the PAH concentrations were below the 10 ug/l cessation criterion when proper purging was performed. The distribution of PAH in the Ironton - Galesville Aquifer was not controlled by pumping well W105. Instead, the relatively low concentrations of PAH and limited distribution of PAH in the Ironton - Galesville Aquifer do not pose unacceptable risks, because the PAH are naturally attenuated and the aquifer is not used for drinking water in the vicinity of the Reilly Site.

PAH entered the Prairie du Chien – Jordan Aquifer via multiaquifer groundwater flow in well W23, including the direct introduction of coal tar-like material as observed on the borehole. According to USGS WSP 2211, contaminants can move fairly rapidly through the Prairie du Chien – Jordan Aquifer because the upper part of this aquifer is a solution channel carbonate rock of high transmissivity and low effective porosity. In St. Louis Park, dissolved PAH were widely distributed in the aquifer in response to pumping changes at the City municipal wells. In particular, well closures due to PAH contamination at wells SLP7, SLP9, SLP10, and SLP 15 were followed later by closures at wells SLP4 and SLP5 as a result of PAH being drawn by wells SLP4 and SLP5 to previously uncontaminated areas of the aquifer.

One of the primary elements of the Reilly Site remedy is to maintain pumping at municipal wells SLP4 and SLP10/15. This pumping has been shown to provide the primary containment which prevents the further spread of PAH in the Prairie du Chien – Jordan Aquifer. A secondary remedial element is the continued pumping at well W23 which helps control the highest concentrations of PAH in the Prairie du Chien – Jordan Aquifer. Well W23 is located on-site and, prior to cleaning in 1982, the well contained coal tar-like materials within the well bore and on the adjacent rock surfaces of the Prairie du Chien Formation. Most if not all of the PAH from the Reilly Site in the Prairie du Chien – Jordan Aquifer migrated via well W23.

Well W410 is an active pumping well in the St. Peter Aquifer that was installed after an investigation of the St. Peter Aquifer was conducted in accordance with Section 8.1 of the CD-RAP. The CD-RAP did not specify pumping rates or cessation criteria for well W410 because the results of the investigation were not available at that time and it was not known that a pumping well would be needed in the St. Peter Aquifer.

The CD-RAP (Section 8.3) states that the purpose of the well is to prevent the further spread of groundwater exceeding any of the CD-RAP drinking water criteria.

Platteville Aquifer pumping wells included well W421 and W434. The CD-RAP identified different qualitative reasons for pumping these wells. Well W421 is an active pumping well that was installed to control the source of contamination in the bog area south of the Reilly Site (CD-RAP Section 9.1.1). Well W434 was installed to prevent the spread of contamination into the buried bedrock valley as mapped by Hult and Schoenburg in USGS Water Supply Paper 2211, Plate 2 (CD-RAP Section 9.7.2). After a four-part evaluation as described below in Section 1.3, pumping at well W434 was ceased in 2006 because the water quality met the MDH Health Risk Limits (HRL) and Maximum Contaminant Levels (MCL) for various PAH compounds.

Drift Aquifer pumping wells included wells W420, W422, and W439. Well W420 is an active pumping well that was installed to control the source of contamination in the bog area (CD-RAP Section 9.1.1). Well W422 was installed to limit the spread of contamination into the buried bedrock valley as mapped by Hult and Schoenburg in USGS Water Supply Paper 2211, Plate 2 (CD-RAP Section 9.2.4). Similar to well W434, pumping at well W422 was ceased in 2000 because the water quality met the HRLs and MCLs for various PAH compounds. Well W439 is an active pumping well that was installed in accordance with Section 9.5.1 of the CD-RAP to limit the spread of contamination within the Northern Area, as defined by the CD-RAP (Section 9.3.1).

1.3 Pumping Cessation

The CD-RAP states that the pumping wells in the St. Peter, Platteville, and Drift Aquifers may cease operation when they are no longer required for the purposes for which they were installed (see CD-RAP Sections 8.3, 9.1.4, 9.2.4, and 9.5.2). Well W422 was removed from service in 2000 and well W434 was removed from service in 2006 because the Agencies agreed with the City's assessment that the cessation criteria had been met. Copies of the relevant correspondence from the Agencies are provided in **Appendix B**. In order to make this determination, the Agencies required a four-part evaluation of cessation. The Agencies December 6, 1999 letter explained the following four elements required for a cessation request:

1. <u>Numeric Cessation Concentrations</u>: Where the CD-RAP identifies qualitative goals such as controlling or limiting the spread of contamination, the Agencies requested numeric criteria used to evaluate potential ceasing of pumping for the Drift, Platteville, and St. Peter Aquifers. Section 2.0 of this report recommends using numeric cessation criteria consisting of current available HRLs and MDH Health Based Values (HBVs) or MCLs for PAH compounds at key monitoring wells (sentry wells).

2. <u>Compliance With Remedial Objectives</u>: This includes hydrogeologic evaluation of the pumping wells and an assessment of the contaminant concentrations and health risks within the areas of the aquifers influenced by the pumping wells. Section 3.0 of this report uses the historic site database to delineate the inferred extent of PAH in groundwater above the MDH HRLs and HBVs and an analysis of the capture zones of each pumping well. An important part of the justification for cessation of pumping is a hydrogeologic evaluation in areas of the aquifers that are unaffected by the pumping, including the area of the buried bedrock valley as mapped by Hult and Schoenburg in USGS Water Supply Paper 2211, Plate 2.

3. <u>Assessment of Contaminant Spreading</u>: The Agencies requested post-cessation monitoring to determine if contaminant migration occurs. In considering cessation of pumping in the non-drinking water aquifers, the City recognizes that future downgradient monitoring at key locations will determine if groundwater that exceeds cessation criteria migrates beyond its current distribution (see Section 4.0). This report proposes well locations and sampling frequencies based on post-cessation monitoring needs.

4. Criteria to Resume Pumping: These numeric criteria are PAH concentrations at specific locations that would trigger a resumption of pumping. Section 5.0 of this report recommends the use of HRL and HBV or MCL PAH concentrations at key locations for this purpose.

The City looks forward to completing the CD-RAP requirements for source and gradient control in the non-drinking water aquifers so that the City and the Agencies may accomplish this milestone in the remedy of the Reilly Site. Part BB of the CD-RAP requires five years of post-cessation monitoring data that demonstrate cessation criteria have been met, in order to obtain certification from the Agencies that the remedial tasks are complete. Given the 30-year milestone for the CD-RAP that is now only four years away, the City believes cessation of pumping at this time would be consistent with the intent of the remedy planned in the CD-RAP.

2.0 CESSATION CONCENTRATIONS

The CD-RAP does not specify numeric cessation criteria, but rather requires that cessation criteria be developed for the Drift, Platteville and St. Peter Aquifer pumping wells. This report proposes a strategy for cessation based on using the current, health-based PAH standards from the MDH, even though the water is not used for drinking water. The current MDH HRLs, HBVs and MCLs are shown in **Table 2**. The HRL shown for naphthalene is 70 micrograms per liter (ug/L) which is a new proposed value that replaces the previous value of 300 ug/L and should become effective in the first quarter of 2013. Using the MDH HRLs and HBVs as cessation criteria in the non-drinking water aquifers is consistent with their prior use in the Drift and Platteville Aquifers as cessation criteria for wells W422 in 2000 and W434 in 2006. The prior Agency approval letters for cessation of pumping at W422 and W434 are included in **Appendix B**.

The use of MDH HRLs and HBVs as cessation criteria for the Drift and Platteville Aquifers does not require a modification to the CD-RAP or a judgment from the court. There is nothing in the CD-RAP that implies that the drinking water criteria specified in CD-RAP Section 2.2 must be used to define the extent of contamination, determine where pumping is needed, or to guide the duration of pumping in these aquifers. In fact, the CD-RAP gives a cessation criterion for well W23 in the Prairie du Chien – Jordan Aquifer of 10 micrograms per liter, approximately 35 times higher than the 280 part per trillion drinking water criterion for Other PAH in the same aquifer. Another way to look at this issue is that PAH from non-Reilly sources such as urban runoff (see Section 3.1.1 in this report and **Appendix C**) may be expected to cause groundwater to exceed the CD-RAP drinking water criteria outside areas controlled by pumping and even beyond areas that may contain Reilly Site PAH. Because criteria other than the drinking water criteria specified in CD-RAP Section 2.2 are being used, the analytical protocol was changed in 2002 to analyze the Drift and Platteville Aquifer samples using part per billion-level detection limits instead of the trace-level part per trillion detection limits.

The CD-RAP does refer to the Section 2.2 drinking water criteria in the St. Peter Aquifer (CD-RAP Section 8.3). This may have been due to the fact that the City once operated wells that obtained drinking water from the St. Peter Aquifer and the aquifer is less susceptible to surficial contamination from other sources. The City's first three municipal wells drew water from the St. Peter Aquifer. Wells SLP1 and SLP2 were abandoned prior to the date of the CD-RAP and well SLP3 is an unused well due to be abandoned in 2013. The City is of the opinion that the decision to turn the pump off at well W410 can be made using cessation criteria different from the CD-RAP drinking water criteria (as was done at wells W23 and W105) and that the CD-RAP objective will still be met, namely, the spread of PAH above the CD-RAP drinking water criteria will be limited.

The City recommends using the HRLs/HBVs as cessation criteria in sentry wells located in downgradient areas. Monitoring of those areas will determine if PAH above the HRLs/HBVs migrate downgradient. New monitoring wells may be installed for that purpose. Section 4 of this report discusses post-cessation monitoring and the use of sentry wells to monitor water quality. The PAH compounds are not expected to spread after cessation of pumping due to their limited mobility.

In order to provide additional context on the use of the HRLs/HBVs, the Reilly Site database was queried to determine the locations and dates of samples that have exceeded the proposed cessation criteria in each non-drinking water aquifer. The results of this review show a much more limited area of contamination compared to prior assessments that were based on CD-RAP drinking water criteria. A copy of the database updated through October 2, 2012 was provided to the Agencies at the same time this report was submitted.

A summary of HRL/HBV exceedances in each aquifer for all the samples collected since monitoring began under the CD-RAP is given in **Tables 3, 4, and 5**. **Table 3** lists the numbers of locations (wells) where the HRLs/HBVs have been exceeded in each aquifer. **Table 4** shows the number of samples that exceeded the HRLs/HBVs in each aquifer. The identities of the samples that exceeded the HRLs/HBVs are presented in

Table 5. Most of the exceedances shown in **Table 5** came from a relatively small number of Drift and Platteville Aquifer wells on or near the Reilly Site. For example, pumping wells W420, W421, and W439 constitute approximately 86% of all exceedances in the Drift and Platteville Aquifers. In the St. Peter Aquifer, three samples collected at well W409 and one sample at well W410 (all prior to 2001) exceeded the HRLs/HBVs. The other samples collected at the St. Peter Aquifer wells were below the HRLs/HBVs.

Together, **Tables 3, 4, and 5** document that the MDH HRLs/HBVs have not been exceeded in most of the groundwater samples collected as part of the CD-RAP for the Reilly Site.

3.0 COMPLIANCE WITH REMEDIAL OBJECTIVES

This section provides a hydrogeologic evaluation of the site and the remedy to assess if remedial goals have been met and if it is appropriate to turn off the pumping wells. Key components of this evaluation include a conceptual site model, a discussion of the fate and transport of PAH at the site, and an assessment of the hydraulic capture afforded by the pumping wells. The current PAH concentrations in the Drift, Platteville, and St. Peter Aquifers, based on recent groundwater monitoring results, are shown on **Figures 3, 4, and 5**, respectively.

3.1 Conceptual Site Model

Conceptual models of the Drift, Platteville, and St. Peter Aquifers are discussed below. Some elements of the conceptual models are the same across each of these aquifers. For example, the geologic setting of these bedrock units is on the west flank of the Twin Cities Basin, thus bedrock slopes gently to the east. Water levels in the bedrock aquifers are lower in progressively deeper layers. Also, a regional hydraulic gradient of 10 feet per mile is common and groundwater generally flows to the east southeast (USGS WSP 2211, Open-File Report 73-203, and WRI Report 90-4150). Another common element to the conceptual models of the Drift, Platteville, and St. Peter Aquifers is that the groundwater is not used as a supply of drinking water.

3.1.1 Drift Aquifer

The Drift Aquifer contains the highest concentrations of PAH due to its susceptibility to surficial contamination from Reilly's former operations. A generalized cross section through the bog area (see CD-RAP Appendix B) is shown on the Conceptual Site Model in **Figure 6**. The glacial sediments that comprise the Drift Aquifer are heterogeneous mixtures of particle sizes and mineral compositions typical of the high-energy environment in which they were deposited. As such, the hydraulic conductivity and other hydrologic properties of the Drift Aquifer vary from place to place. The three dimensional orientation of the glacial sediments were generally described by the USGS (WSP 2211) and include the upper, middle, and lower drift as shown on **Figure 6**. The three-dimensional variations in hydraulic conductivity that determine the actual extent of the capture areas of individual pumping wells are not well known. Thus the calculations of groundwater flow in the Drift Aquifer (see Section 3.3.1 below) require assumptions that may not match actual conditions.

Coal tar-like materials have been observed in wells on site (e.g., well W23 during examination/rehabilitation) and in the bog area south of the site (e.g., well W13). These materials have provided a constant source of PAH to Drift Aquifer wells for many decades, at least as early as 1932 when contamination problems at the Reilly Site were first documented (MDH 1938). Thus, at least 56 years elapsed prior to the start of the pumping required by the CD-RAP, during which time PAH were present in the environment. The bog area historically had the highest concentrations of PAH, and one former Drift Aquifer well (W13) contained DNAPL (USGS WSP 2211). The peat and organic soil common in the bog area, as shown on **Figure 6**, have a demonstrated capacity to adsorb PAH.

The Drift Aquifer also receives PAH from non-Reilly anthropogenic sources, as evidenced by water quality analyses of storm water. Total PAH concentrations in typical urban surface water runoff are higher than the CD-RAP drinking water criteria. Prior work done for the Reilly Site included a Feasibility Study Report for the discharge from well SLP4 (Barr, 1987) and an evaluation of groundwater alternatives funded by MPCA (CH2MHill, 1983). Both studies referenced PAH analyses for area storm water samples that contained total PAH concentrations in the range of 2 to 3 micrograms per liter. A map of the sampling locations and a table of analytical results are provided in **Appendix C**.

3.1.2 Platteville Aquifer

PAH concentrations in the Platteville Aquifer follow the same general pattern as in the Drift, but their magnitude is typically less. There is no laterally persistent confining layer to block migration between the Drift and Platteville Aquifers (hence they are often modeled as one unit). PAH from the Reilly Site have migrated downward through the Drift and into the Platteville Aquifer.

Coal tar-like materials have been observed in the Platteville Aquifer at well W23 on site, and recently in well W421 downgradient of the bog area off site. The coal tar-like materials in well W23 likely entered the Platteville Aquifer prior to 1932 when casing was added from the top of the well to a depth of approximately 80 feet. Prior to 1932 well W23 was open to the Platteville Aquifer and down-hole flow led to contamination at the City's first municipal well (well W112, MN Unique No. 206443, now abandoned). The coal tar-like materials recently found in well W421 likely migrated to that location as a result of the long term pumping at wells W421 and W420. When wells W421 and W420 are not pumping, there is an upward hydraulic gradient locally from the Platteville towards the Drift. The upward gradient was demonstrated by transducer data from wells W9 and W18, which indicate a higher non-pumping head in the Platteville Aquifer (well W18) compared to the Drift Aquifer (well W9) as illustrated in **Figure 7.** Well W421 was not pumping at the time the water levels were measured in the Drift (well W9) and Platteville (well W18) monitoring wells across Lake Street from well W420. As shown in **Figure 7**, even with a low flow pumping rate at well W420, the elevation of the Platteville Aquifer water level was below the Drift Aquifer water level. The upward gradient would tend to limit the spread of PAH from the Drift into the Platteville during non-pumping conditions at this location.

Referring to the Platteville Formation as an aquifer is an oversimplification of the hydrologic properties of this bedrock unit. The Platteville Formation consists of four members which have different physical characteristics where it is observed in outcrops. In particular, many springs occur at outcrops within the Hidden Falls member, and the underlying thickness of the Platteville Formation (Mifflin and Pecatonica members) has been characterized as an aquitard (MGS, 2011). **Appendix D** contains the MGS presentation that suggests that wells open to the Platteville Formation may derive most of their water from a relatively thin transmissive zone. In St. Louis Park, drilling records for some wells (e.g., W434 and W411, see **Appendix E**) show that only a partial thickness of weathered Platteville Formation is present. It is likely that some Platteville wells derive water from this weathered zone, even if this zone is part of the aquitard where it is not weathered. The known heterogeneity of the Platteville Formation results in uncertainty in calculating the capture area of well W421 as discussed in Section 3.3.1 below.

Underlying the Platteville Formation is the Glenwood Shale, a thin, but important confining layer in the Reilly Site area. The Glenwood Shale is not always noted on driller's logs because it is commonly less than five feet thick. However, it is an effective barrier to vertical groundwater flow and it separates the shallow aquifers from the underlying St. Peter Aquifer. Typically there is 10 feet of head difference across the Glenwood Shale, as was measured on December 6, 2012 at wells W414 and W415 (**Table 7**).

3.1.3 St. Peter Aquifer

Compared to the Drift and Platteville Aquifers, the hydrologic properties of the St. Peter Aquifer fall within a very tight range, and there is much more certainty in the routine capture zone calculations discussed in Section 3.3.3 below. The St. Peter Aquifer is a fine to medium grained quartzose sandstone that has been the subject of numerous hydrogeologic studies. The basal St. Peter Formation is considered a confining layer in many areas and separates the St. Peter Aquifer from the Prairie du Chien – Jordan Aquifer. It consists of inter-bedded sandstone and shale which inhibits vertical groundwater flow, but allows horizontal groundwater flow through the sandstone layers. Well W122 is the only Reilly Site monitoring well completed in the basal St. Peter Formation (see **Appendix E** for the log of this well). The effectiveness of the confining layers above and below the St. Peter Aquifer is demonstrated by water level differences across those layers as measured in Reilly Site monitoring wells (see Section 3.3.3 of this report and AECOM, 2011).

The St. Peter Aquifer was subject to contamination via down-hole flow in uncased or ungrouted wells both on and off site. Examples of wells that allowed Drift or Platteville contamination to migrate into the St. Peter Aquifer include well W22, W23, W25, W26, W27, and W33. All of these wells were investigated and reconstructed prior to the effective date of the CD-RAP to eliminate the pathway for contaminant migration. It is not clear from the monitoring data that PAH traveled to the St. Peter Aquifer via buried bedrock valleys, however, it is clear that concentrations of PAH that may have travelled in that manner were below MDH HRLs/HBVs.

3.2 Fate and Transport of PAH

PAH compounds are biodegradable, and several researchers have published the results of studies that demonstrate the mechanisms, rates, and other details of PAH biodegradation in groundwater (Fraser, et al. 2008, Zamfirescu and Grathwohl, 2001). The researchers have shown that aerobic degradation removes most of the lighter, two-ring and three-ring PAH compounds (e.g., naphthalene and acenaphthene are two-ring PAH), as well as lighter compounds such as benzene and phenols that may be present in a coal tar source (Fraser, et al. 2008, Zamfirescu and Grathwohl, 2001). Heavier PAH compounds, especially carcinogenic PAH, are more generally resistant to biodegradation and are less mobile in the environment (Fraser, et al. 2008, Zamfirescu and Grathwohl, 2001).

The pattern of groundwater PAH concentrations at the Reilly Site is similar to the biodegradation pattern described in the literature. This is illustrated by naphthalene and acenaphthene concentrations in groundwater samples. Near the source areas at the Reilly Site, naphthalene is the dominant PAH compound found in the groundwater. This is because naphthalene comprises approximately 10% of the coal tar and creosote source material. Thus, the pumping wells adjacent to the bog area, wells W420 and W421, contain high concentrations (hundreds to thousands of micrograms per liter) of naphthalene. **Figures 3 and 4** contain isoconcentration maps of naphthalene data collected in 2012 for the Drift and Platteville Aquifers. Naphthalene and the lighter coal tar compounds comprise a large fraction of the total PAH in the bog area and are the energy (food) source for the microorganisms that consume them.

In an idealized biodegradation setting, as distance from the source increases, all PAH concentrations decrease in downgradient areas due to various natural attenuation phenomena and naphthalene is removed below detection limits. The literature has shown that the mass of acenaphthene becomes greater than the mass of other PAH compounds downgradient from the source (Fraser, et al. 2008, Zamfirescu and Grathwohl, 2001). This pattern is observed at the Reilly Site in nearly all of the downgradient wells due to acenaphthene's relative resistance to biodegradation compared to naphthalene, and its greater mobility compared to heavier PAH compounds. This is illustrated on the acenaphthene distribution maps in **Figures 3 and 4.** Also in the downgradient direction, biodegradation becomes less and less prevalent as the energy source (i.e., naphthalene) decreases.

Figures 3 and 4 also contain a map of the fraction of total PAH consisting of acenaphthene. Many downgradient wells contain mostly acenaphthene or 100% acenaphthene. **Figures 8 and 9** are graphs that show the total PAH concentrations in the former pumping wells W422 and W434. With these wells no longer pumping, 100% of the PAH present is acenaphthene. This illustrates that under natural, non-pumping flow conditions, acenaphthene is the dominant PAH compound found in downgradient groundwater. Acenaphthene and other PAH are attenuated by sorption and dispersion in the downgradient areas where biodegradation is largely absent. Thus, the downgradient extent of PAH is limited by retardation and acenaphthene concentrations are below the MDH HRL.

Groundwater monitoring data collected since the effective date of the CD-RAP are discussed below for each aquifer. Maps showing groundwater PAH concentrations at the outset of pumping are compared to recent isoconcentration maps. The maps show that the water quality has changed little over the years, thus it is apparent that natural attenuation has limited the spread of PAH outside the capture areas of the pumping wells.

Pumping has increased PAH concentrations at some wells. For example PAH concentration increased at St. Peter Aquifer well W409 (Appendix A, page 35) and then decreased after 2000, apparently in response to less PAH available to migrate into well W409. St. Peter Aquifer well W410 (Appendix A, page 36) is the pumping well which has shown an increasing trend of PAH concentration since 2002. Platteville Aquifer well W421 (Appendix A, page 40) has shown an increasing trend since 2006. This downgradient spread of higher PAH concentrations (and DNAPL in the case of well W421) was an unintended consequence of groundwater pumping for the Reilly Site Remedy. However, the low mobility of PAH compounds is expected to limit their spread once the pumping stresses are replaced by natural flow conditions.

Figures 10, 11, and **12** are PAH isoconcentration maps for the Drift, Platteville, and St. Peter Aquifers, respectively. The concentration intervals selected are the CD-RAP drinking water criteria for OPAH (0.280 ppb) and the MDH HRL for naphthalene (70 ppb).These figures show the sum of PAH concentrations for four different sampling events. It is important to remember that beginning in 2001 the Drift and Platteville monitoring switched from part per trillion to part per billion level detection limits. As a result more “ND” results were obtained. Also, in 2010 the analytical parameter list for these aquifers was trimmed from the 31 PAH listed in the CD-RAP to the 16 priority pollutant PAH. Post 2010 PAH sums are therefore based on fewer compounds. Some of the apparent differences in the maps shown in **Figures 10, 11,** and **12** are a result of these analytical changes. Also, the sample locations were not consistent from sampling round to sampling round, and those differences greatly affect the data interpolation resulting in maps that appear different, regardless of actual changes in groundwater PAH concentrations that may have occurred.

The Reilly Site database can be used to create any or all of a full set of maps for each sampling round and any individual PAH compound or sum of multiple PAH compounds. The sum of all PAH compounds shown for the four time periods selected for **Figures 10, 11,** and **12** are intended to be representative of conditions at the Reilly Site. New maps showing other sampling events or other PAH data are available upon request.

3.2.1 Drift Aquifer

Figure 10 shows the distribution of total PAH in Drift Aquifer at four different times since monitoring began in 1988 in accordance with the CD-RAP. The logarithmic contours represent the sum of all PAH detected in each sample. The highest concentrations are in the source areas on and near the Reilly Site. Dissolved PAH at concentrations below MDH HRLs/HBVs are present in a plume extending downgradient to the east southeast. **Figure 10** illustrates that, given the caveats discussed above regarding differences in sample locations and analytical methods, the general pattern of PAH contamination in the Drift Aquifer has not changed dramatically from the late 1980s to the present. The source area near the bog contains the highest PAH concentrations and downgradient PAH concentrations are lower and variable.

3.2.2 Platteville Aquifer

Figure 11 shows total PAH concentrations in the Platteville Aquifer at eight-year intervals since monitoring began in accordance with the CD-RAP. The logarithmic contours represent the sum of all PAH detected in each sample. The highest concentrations are in the source areas on and near the Reilly Site. Dissolved PAH at concentrations below MDH HRLs/HBVs are present in a plume extending downgradient to the east southeast. **Figure 11** illustrates that the extent and magnitude of PAH contamination in the Drift Aquifer has not changed from the late 1980s to the present.

3.2.3 St. Peter Aquifer

Figure 12 shows PAH concentrations in the St. Peter Aquifer at eight-year intervals since monitoring began in accordance with the CD-RAP. After pumping began at well W410 in 1990, wells W409 and W410 showed changes in PAH concentrations that indicate the spread of PAH from the vicinity of the Reilly Site downgradient into well W410. With the exception of naphthalene in three samples from well W409 prior to September 2000, and one sample from well W410 that contained CPAH above the HBV, the water quality in every sample from every well completed in the St. Peter Aquifer has always met the MDH HRLs and HBVs since sampling began in accordance with the CD-RAP.

3.3 Capture Zone Analysis

3.3.1 Drift/Platteville Aquifer Source Control

According to CD-RAP Sections 9.1.1 and 9.1.4, the purpose of wells W420 and W421 are to control the flow of groundwater and the source of contamination within the geographic confines of the bog area defined as Walker Street on the north, the former temporary Louisiana Avenue on the east, Lake Street and South Frontage Street Extension on the south, and a north-south line extending from the intersection of Walker Street and West 37th Street on the west.

A slightly different rational for source control is given in the OU2 Record of Decision (ROD): “The purpose of source control is to limit further migration of relatively highly contaminated ground water that would otherwise contaminate the St. Peter Aquifer which has drinking water quality and use; and, to protect areas of the Drift/Platteville Aquifers that are not yet contaminated by leachate from the Reilly Site.” (EPA,1986). This ROD languages implies that every molecule of PAH was not intended to be controlled because it only references highly contaminated groundwater and leachate.

According to the CD-RAP Section 9.5.1, the purpose of pumping well W439 is to limit the further spread of contamination in the Northern Area. The Northern Area is bounded by West 32nd Street to the north, Alabama Avenue to the east, Highway 7 to the south, and Louisiana avenue to the west. EPA’s OU5 ROD (EPA, 1995) does not use different language to describe the purpose of pumping well W439. However, of interest the ROD includes the following statement: “On the basis of their relatively large volume and low mobility, residual PAHs are expected to remain in the aquifer for at least the 30-year life of the CD/RAP.” That expectation has been met according to the Reilly Site groundwater monitoring data.

Under existing pumping conditions, groundwater within the estimated capture areas of wells W420, W421, and W439 contain PAH concentrations above the MDH HRLs/HBVs. **Figure 13** shows the capture zones of W420 and W439 overlaying a potentiometric surface map generated using groundwater elevation data collected manually during the June 2009 sampling event. These data were used because more wells were monitored thus more data are available, and the hydrogeologic conditions in 2009 are representative of current conditions. The potentiometric surface was interpolated using ordinary kriging with a quantile transformation. The capture zones were calculated using methods adapted from Javandel Tsang (1986). The following parameters were used in the analysis:

	Q, ft^3/day	K, ft/day	i	b, ft
W420	7,701	80	0.002	60
W439	11,166	80	0.002	60

Note: Q = pumping rate at each well, K = horizontal hydraulic conductivity using Metro Model mean, i = horizontal hydraulic gradient using average regional gradient per USGS WSP 2211, and b = aquifer thickness using the approximate drift thickness in wells W33R, W421, and W429.

A capture zone was not calculated for well W421 due to the great uncertainty in the hydrologic properties of the Platteville Aquifer. The Drift and Platteville Aquifers are hydraulically connected and Platteville Aquifer monitoring wells W18 and W426 have shown drawdown as a result of pumping in the Drift Aquifer at wells W420 and W439, respectively. Therefore, the capture zone of well W421 is augmented by pumping at well W420. The drawdown response at well W18 may indicate a capture zone in the Platteville Aquifer similar to the one shown on **Figure 13** for well W420 in the Drift Aquifer.

Under future non-pumping conditions, the groundwater will continue to contain PAH concentrations above the MDH HRLs/HBVs, and downgradient migration of PAH will be limited as discussed above. The extent to which PAH might desorb from the peat and organic soil in the source area and migrate as dissolved constituents in groundwater is estimated to be small (concentrations below MDH HRLs/HBVs), based on the relatively low concentrations of PAH that were present downgradient from the bog area at the outset of monitoring (**Figures 10 and 11**). If PAH migration occurs such that concentrations exceed the MDH HRLs/HBVs in downgradient areas (at the sentry wells described in Section 4.0) then source area pumping would resume.

3.3.2 Protection of the Buried Bedrock Valley

Wells W420, W421, and W439 were not designed or required to provide direct protection of the buried bedrock valley as mapped by USGS Water Supply Paper 2211, however preventing PAH from migrating into the St. Peter Aquifer via the buried valley was a goal for the Drift Platteville gradient control well W422 as described in Section 9.2.4 of the CD-RAP, and was a goal for well W434. Since wells W422 and W434 are no longer pumping, it is worthwhile to assess ongoing protection of the buried bedrock valley. The comprehensive Reilly Site database indicates that groundwater with PAH concentrations above the MDH HRLs/HBVs has not travelled as far as either arm of the buried valley mapped by USGS Water Supply Paper 2211 and PAH concentrations above the MDH HRLs/HBVs have not been found in any water samples from wells completed in the St. Peter Aquifer below the valley. This is shown on **Figures 3, 4, and 5**. The groundwater monitoring plans described in Section 4.0 include the sentry wells and other wells that will determine if post-cessation PAH migration toward or through the buried valley is a concern.

The buried valley was mapped by USGS in the early 1980s and consists of an eastern arm and a western arm. The western arm was described in WSP 2211: “No well or test boring clearly indicates the presence of a deep bedrock valley in this area; therefore, the valley may be absent of much shallower than shown.” Recent investigations and information suggest that the buried valley is shaped differently or may not even be present in key areas mapped by USGS. The information indicates that the western arm of the buried valley mapped by USGS does not exist (Minnesota Geological Survey, 1965 and 1986) or is located elsewhere (MGS, 2000). A review of the maps indicates that the buried valley is 2300 feet farther from the Reilly Site than is depicted by USGS WSP 2211. **Appendix G** provides copies of the MGS buried bedrock valley maps with a trace of the USGS WSP 2211 bedrock valley superimposed.

3.3.3 St. Peter Aquifer Gradient Control

According to CD-RAP Section 8.3, the purpose of pumping well W410 is to prevent the further spread of groundwater exceeding any of the CD-RAP drinking water criteria. EPA’s OU4 ROD (EPA, 1990) mirrors this objective and contains the same language regarding residual PAH as the OU5 ROD for the Northern Area. No specific geographical area was cited to be controlled by well W410. Prolonged pumping at well W410 has drawn higher concentrations of PAH from the vicinity of the Reilly Site into the pumping well (**Appendix A, page 65**). However, as shown in **Tables 3, 4, and 5**, groundwater samples from the St. Peter Aquifer monitoring wells currently meet (and have nearly always met) the MDH HRLs/HBVs.

The relatively broad capture area of pumping well W410 shown in **Figure 14** is the result of the hydrogeologic properties and relative uniformity of the St. Peter Aquifer (MGS, 2003). Aquifer testing in the past has shown remarkable consistency in the hydrologic results, as noted in the St. Peter Aquifer Feasibility Study Report submitted in accordance with CD-RAP Section 8.2.2. The capture area shown in **Figure 14** was calculated using a pumping rate of 53 gallons per minute in well W410, a gradient of 10 feet per mile (USGS WRI Report 90-4150), a hydraulic conductivity of 13 feet per day (Metro Model mean) and an aquifer thickness of 100 feet (well log for W23).

The St. Peter Formation includes the approximately 100-foot thick aquifer and a lower confining layer that consists of interbedded sandstone and shale that is approximately 50 feet thick. Well logs for wells W23, W29, W32, W34, and W45 (summarized in USGS WSP 2211) show an average thickness of 105 feet in the St. Peter Aquifer and 55 feet in the basal confining layer. The shale layers are an effective barrier to vertical flow, as evidenced by the difference between the St. Peter Aquifer and the Prairie Du Chien – Jordan Aquifer. This head difference is reported in the literature (USGS Open-File Report: 73-203) and has been measured in St. Louis Park. For example, in 2011 the static water level in well SLP10 (810.81 on Figure 2 of the 2011 Annual Monitoring Report) was over 60 feet lower than the water level in nearby well W408 (873.66 on Figure 5 of the 2011 Annual Monitoring Report).

4.0 ASSESSMENT OF CONTAMINANT SPREADING

4.1 Monitoring plan

The 2013 Sampling Plan contains the basic groundwater monitoring plan for the Drift, Platteville, and St. Peter Aquifers assuming no change in pumping. Additional wells will be selected for monitoring to provide data for assessing the potential spread of PAH if the wells are not pumping. The proposed list of additional wells to be monitored in 2013 is included in **Table 6**. The additional wells will be sampled and analyzed in accordance with the same field and analytical procedures described in the 2013 Sampling Plan.

Appendix H contains a plan for installing new monitoring wells to be added to the groundwater monitoring program. **Figure 15** shows the proposed locations of new Drift and Platteville Aquifer sentry wells to be added to the monitoring program to evaluate cessation. Upon approval of this cessation request, the new wells will be installed downgradient from the plume as defined by water that exceeds the MDH HRLs/HBVs. Since existing monitoring data do not pinpoint this location, it may take an iterative process of installing wells close to and downgradient from the source area, and collecting PAH data from the new well, to ultimately identify the sentry well.

In addition to the Drift, Platteville, and St. Peter Aquifer monitoring described in the 2013 Sampling Plan, the City will collect annual samples at the sentry wells described in **Appendix H** and at the following wells to monitor potential post-cessation contaminant spreading:

4.2 Sentry Wells

The new Drift and Platteville Aquifer sentry wells described in **Appendix H** will be located on City-owned property, along Lake Street. The City proposes to use well W33R as the St. Peter Aquifer sentry well. Well W33R is a fully penetrating well located near the source area.

Sentry wells in each aquifer will provide samples to monitor groundwater PAH concentrations and evaluate the potential need to resume pumping. The downgradient edge of the plume is not expected to change appreciably as a result of cessation of pumping, however, pumping would resume if the water quality results from the sentry wells exceed the MDH HRLs and/or HBVs. Specifically, if samples from the Drift Aquifer sentry well exceed the MDH HRLs/HBVs then wells W420 and W439 would restart pumping. If samples from the Platteville Aquifer sentry well exceed MDH HRLs/HBVs, then well W421 would restart pumping. And, if samples from well W33R exceed the MDH HRLs/HBVs then well W410 would restart pumping. Post-cessation monitoring of the wells listed in Table 6 will provide the data needed to document potential water quality changes and provide an accurate picture of the residual PAH concentrations in groundwater.

4.3 Well Maintenance

During the five year post-cessation monitoring period, wells W420, W421, W439, and W410 will be used for sampling as indicated in 2012 Sampling Plan. The well houses, pumps, and discharge piping will be maintained such that the wells could resume pumping if the sentry wells exceed the MDH HRLs or HBVs.

4.4 CD-RAP requirements

The duration of the CD-RAP is discussed in Part BB. Individual remedial elements, including Drift, Platteville, and St. Peter Aquifer source and gradient control wells, may be completed on or after the 30^{th} anniversary of the CD-RAP, and if the Agencies approve completion of any remedial element, then the CD-RAP requirements for that specific remedial element (and contingencies) “shall be terminated by the Court”. According to Part BB the Agencies require five years of post-cessation monitoring data (showing no need to resume pumping) in order to approve completion of the pumping well remedial elements. Assuming the pumping wells are turned off in 2012, then there will be five years of post-cessation monitoring data available in 2017, which is the 31^{st} anniversary of the CD-RAP. The City desires to petition the Agencies for completion of the Drift, Platteville, and St. Peter Aquifer source and gradient control remedial elements at the earliest possible date.

5.0 Conclusion

5.1 Drift – Platteville Aquifer

Coal tar materials and creosote from the Reilly Site entered the Drift – Platteville Aquifer system at the ground surface since the beginning of Reilly's operations in 1917. By the time environmental studies had been done and the CD-RAP had been developed, PAH were widespread in the Drift –Platteville Aquifer and were concentrated in the source areas on site and in the bog area south of the site. Biological degradation removed naphthalene and a portion of the other more easily degraded PAH compounds in the source area. Higher molecular weight PAH that were not biodegradable were sorbed to the soils and aquifer matrix, especially the peat and organic soils in the bog area. As a result of these natural phenomena, the plume areas where groundwater concentrations exceed MDH HRLs/HBVs for PAH compounds are relatively small.

The CD-RAP provides for cessation of pumping when the wells are no longer needed for the purposes for which they were installed. The CD-RAP does not require that the groundwater meets CD-RAP drinking water quality. The groundwater monitoring data prove that PAH have limited mobility and are present in groundwater in concentrations below current drinking water standards downgradient from the Reilly Site and bog area.

The City requests the Agencies' approval for cessation of pumping in Drift - Platteville Aquifer wells W420, W421, and W439. Long-term groundwater monitoring at the new sentry wells and at other Drift-Platteville Aquifer monitoring wells will continue to track the distribution of PAH and eventually fulfill the CD-RAP requirements for completion of these remedial elements. The City will maintain the wells so that, if needed, pumping can be re-started.

5.2 St. Peter Aquifer

Coal tar materials and dissolved PAH entered the St. Peter Aquifer via well W23 and other multi-aquifer wells near the Reilly Site (e.g., W26, W27, W33 and others). For the most part, the concentrations of PAH have not exceeded the MDH HRLs/HBVs in samples from St. Peter Aquifer wells. Pumping well W410 has had widespread hydraulic effects due to the nearly uniform and horizontally homogeneous nature of the sand and other hydrogeologic characteristics of the St. Peter Aquifer. PAH were re-distributed in the aquifer as a result of this pumping, however, PAH concentrations appear to have stabilized around the margins of the well W410 capture area.

The City formerly operated one municipal well, namely SLP3, that obtained water from the St. Peter Aquifer. Since, 1986 SLP3 has been operated only as an emergency source of water during peak demand periods. The city no longer needs the well to meet peak demands, and thus well SLP3 is scheduled for abandonment in 2013 in accordance with the City's well head protection plan.

The City requests the Agencies' approval for cessation of pumping in St. Peter Aquifer well W410. Long-term groundwater monitoring will continue to track the distribution of PAH and will eventually fulfill the CD-RAP requirements for completion of this remedial element. The City will maintain well W410 so that pumping can be re-started, if needed.

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Tables

Table 1 Pumping Well Summary

Well ID	Aquifer	Date Pumping Started	Approximate Pumping Rate, GPM	CD-RAP Cessation Criteria	Date Pumping Stopped	Comments
W23	Prairie du Chien - Jordan	1987	50	10 ug/l Total PAH	Still Pumping	Expect to keep pumping. Quantitative CD-RAP cessation criterion may not be met for many years.
W105	Ironton-Galesville	1987	NA	10 ug/l Total PAH	12/13/1991	Pumped the CD-RAP minimum of 5 years. The cessation criterion was met at the outset of pumping.
W410	St. Peter	5/30/1991	50	Cease pumping when the well is no longer needed to control the flow of groundwater exceeding Drinking Water Criteria	Still Pumping	Candidate for cessation. Well meets HRL and HBV criteria.
W420	Drift	1988	30	Cease pumping when the well is no longer needed to control the source of contamination in the bog area	Still Pumping	Candidate for cessation. CD-RAP qualitative criterion has been met and long-term monitoring will continue to document natural attenuation.
W421	Platteville	1988	25	Cease pumping when the well is no longer needed to control the source of contamination in the bog area.	Still Pumping	Candidate for cessation. CD-RAP qualitative criterion has been met and long-term monitoring will continue to document natural attenuation.
W422	Drift	1988	NA	Cease pumping when the well is no longer required to limit the spread of contamination into the buried bedrock valley.	10/1/2000	Agencies approved cessation based on water quality results.
W434	Platteville	6/10/1997	NA	Cease pumping when the well is no longer required to limit the spread of contamination into the buried bedrock valley.	3/23/2006	Agencies approved cessation based on water quality results.
W439	Drift	1/3/1995	50	Cease pumping when the well is no longer required to limit the spread of contamination within the Northern Area.	Still Pumping	Candidate for cessation. CD-RAP qualitative criterion has been met.
SLP10/15	Prairie du Chien - Jordan	1985	1000	Raw water must meet Drinking Water Criteria.	Still Pumping	One or the other of these wells will continue pumping to provide municipal water supply. GAC treatment is expected to continue (at any level of PAH).
SLP4	Prairie du Chien - Jordan	1989	1000	Raw water must meet Drinking Water Criteria.	Still Pumping	This well will continue pumping to provide municipal water supply. GAC treatment is expected to continue (at any level of PAH).

Table 2: Proposed Cessation Criteria for Drift, Platteville, and St. Peter Aquifers

Compound	MDH HBV[1] (ppb)	MDH HRLs[2] (ppb)	Proposed Cessation Criteria (ppb)[3]
cPAH:			
Benzo(a)pyrene Equivalents	0.05	-	0.05
Other PAH:			
Acenaphthene	-	400	400
Anthracene	-	2,000	2,000
Fluoranthene	-	300	300
Fluorene	-	300	300
Naphthalene	-	70	70
Pyrene	-	200	200

1. Health Based Value for benzo(a)pyrene (BaP) Equivalents

2. Health Risk Limits for the only priority pollutant PAH listed by the MDH.

3. The U.S. EPA Maximum Contaminant Level (MCL) for benzo(a)pyrene is 0.2 ppb. The City would not object to using this as an alternate cessation criterion for carcinogenic PAH.

Table 3 Numbers of Wells
With MDH HRL/HBV Exceedances

		Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)
Parameter		Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)
CAS No.		83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
Sample Location								
Drift (No. of Wells Exceeded)		**1**	**--**	**1**	**1**	**4**	**1**	**6**
W6*		Y	--	Y	Y	Y	Y	Y
W9		--	--	--	--	Y	--	--
P308		--	--	--	--	--	--	Y
P309		--	--	--	--	--	--	Y
W10		--	--	--	--	--	--	Y
W15		--	--	--	--	--	--	Y
W420		--	--	--	--	Y	--	Y
W422		--	--	--	--	--	--	--
W439		--	--	--	--	Y	--	--
Platteville (No. of Wells Exceeded)		--	--	**1**	--	**5**	**1**	**5**
W18		--	--	--	--	Y	--	--
W27		--	--	--	--	Y	--	Y
W131		--	--	--	--	--	--	Y
W421		--	--	Y	--	Y	Y	Y
W426		--	--	--	--	Y	--	--
W434		--	--	--	--	--	--	Y
W437		--	--	--	--	Y	--	--
W438		--	--	--	--			Y
St. Peter (No. of Wells Exceeded)		--	--	--	--	**1**	--	**1**
W409		--	--	--	--	Y	--	--
W410		--	--	--	--	--	--	Y
Prairie Du Chien - Jordan (PCJ)		--	--	--	--	--	--	**2**
W23		--	--	--	--	--	--	Y
W403		--	--	--	--	--	--	Y

Notes:
W6* = This well was abandoned in 2005
Y = Analyte detected at least once above the HRL/HBV at this location
-- = Analyte not detected above HRL/HBV
HRL = Health Risk Limit (Mn Department of Health)
HBV = Health Based Value (Mn Department of Health)
BaP Equivalents (Sum 7) = Total Benzo(a)pyrene (BaP) Equivalents (MPCA c-w3-01.xls).
This sum includes Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(j)fluoranthene (co-eluting), Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Benzo(a)pyrene).

Table 4 Summary of Samples
With MDH HRL/HBV Exceedances

Parameter		Acenaphthene			Anthracene			Fluoranthene			Fluorene		
CAS No.		83-32-9			120-12-7			206-44-0			86-73-7		
Limit		400 (ug/L) HRL			2000 (ug/L) HRL			300 (ug/L) HRL			300 (ug/L) HRL		
Sample Location		**Exceeded**	**Samples**	**Percent**	**Exceeded**	**Samples**	**Percent**	**Exceeded**	**Samples**	**Percent**	**Exceeded**	**Samples**	**Percent**
Drift		1	589	0.17	0	588	0.00	1	589	0.17	1	589	0.17
Platteville (OPVL)		0	709	0.00	0	709	0.00	6	709	0.85	0	709	0.00
St. Peter (OSTP)		0	552	0.00	0	552	0.00	0	552	0.00	0	552	0.00
Prairie Du Chien - Jordan (PCJ)		0	623	0.00	0	623	0.00	0	623	0.00	0	623	0.00
CJDN		0	106	0.00	0	106	0.00	0	106	0.00	0	106	0.00
IGV		0	34	0.00	0	34	0.00	0	34	0.00	0	34	0.00
CMSH		0	93	0.00	0	93	0.00	0	93	0.00	0	93	0.00
Total		1	2706	0.04	0	2705	0.00	7	2706	0.26	1	2706	0.04

Parameter		Naphthalene			Pyrene			BaP_Equivalents(Sum)_All		
CAS No.		91-20-3			129-00-0			Not Assigned		
Limit		70 (ug/L) HRL			200 (ug/L) HRL			0.05 (ug/L) HBV		
Sample Location		**Exceeded**	**Samples**	**Percent**	**Exceeded**	**Samples**	**Percent**	**Exceeded**	**Samples**	**Percent**
Drift		181	576	31.42	1	589	0.17	9	589	1.53
Platteville (OPVL)		126	694	18.16	6	709	0.85	49	709	6.91
St. Peter (OSTP)		3	546	0.55	0	552	0.00	1	552	0.18
Prairie Du Chien - Jordan (PCJ)		0	619	0.00	0	622	0.00	11	616	1.79
CJDN		0	106	0.00	0	106	0.00	0	103	0.00
IGV		0	34	0.00	0	34	0.00	0	33	0.00
CMSH		0	93	0.00	0	93	0.00	0	93	0.00
Total		310	2668	11.62	7	2705	0.26	70	2695	2.60

Notes:
ug/L = micrograms-per-liter
Exceeded = Parameter detected above the Consent Decree limit
Samples = Number of times that analyte has been sampled for
Percent = (Exceeded/Samples)*100
HRL = Health Risk Limit (Mn Department of Health)
HBV = Health Based Value (Mn Department of Health)
BaP Equivalents (Sum 7) = Total Benzo(a)pyrene (BaP) Equivalents (MPCA c-w3-01.xls).
This sum includes Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(j)fluoranthene (co-eluting), Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Benzo(a)pyrene).

Table 5 Identification of Samples with MDH HRL/HBV Exceedances

				Parameter		Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)_All
				CAS No.		83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
				Limit		400	2,000	300	300	70	200	0.05
				Limit Type		HRL	HRL	HRL	HRL	HRL	HRL	HBV
				Unit		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aquifer		**Sample Location**	**Sample Date**	**Modifier**								
Drift		P308	9/22/2010 10:05			3.6	<0.020	<0.020	<0.020	0.31	<0.020	0.136
Drift		P309	6/1/2010 13:45			7.6	0.31	0.52	0.56	1.9	0.47	0.0757
Drift		W10	6/21/1989 0:00			ND	0.081	2.3	ND	0.087	1.7	0.2313
Drift		W10	5/30/1990 0:00			0.13	0.2	0.88	0.15	0.17	0.67	0.224
Drift		W15	2/13/1992 0:00			0.44	0.51	1.6	0.26	0.2	0.97	0.28844
Drift		W420	9/21/1988 0:00			68	ND	ND	22	1700	ND	ND
Drift		W420	12/28/1988 0:00			33	ND	ND	6.8	470	ND	ND
Drift		W420	3/29/1989 0:00			69	ND	ND	22	1500	ND	ND
Drift		W420	6/29/1989 0:00			90	ND	ND	30	2400	ND	ND
Drift		W420	9/27/1989 0:00			96	ND	ND	35	820	ND	ND
Drift		W420	12/13/1989 0:00			79	ND	ND	26	2200	ND	ND
Drift		W420	3/27/1990 0:00			150	ND	ND	44	2400	ND	ND
Drift		W420	5/31/1990 0:00			75	ND	ND	24	1200	ND	ND
Drift		W420	8/24/1990 0:00			83	ND	ND	27	2200	ND	ND
Drift		W420	12/21/1990 0:00			62	ND	ND	21	2200	ND	ND
Drift		W420	3/28/1991 0:00			120	ND	ND	38	2600	ND	ND
Drift		W420	6/27/1991 0:00			53	ND	ND	ND	1800	ND	ND
Drift		W420	9/18/1991 0:00			130	ND	ND	96	3200	ND	0.39
Drift		W420	10/16/1991 0:00			91	ND	ND	28	3000	ND	ND
Drift		W420	2/13/1992 0:00			67	ND	ND	22	720	ND	ND
Drift		W420	6/22/1992 0:00			85	ND	ND	25	2400	ND	ND
Drift		W420	9/8/1992 0:00			57	ND	ND	ND	1637	ND	ND
Drift		W420	11/17/1992 0:00			66	ND	ND	20	1600	ND	ND
Drift		W420	3/23/1993 0:00			77	ND	ND	ND	1800	ND	ND
Drift		W420	4/27/1993 0:00			87	ND	ND	25	2500	ND	ND
Drift		W420	8/17/1993 0:00			52	ND	ND	ND	1300	ND	ND
Drift		W420	10/12/1993 0:00			64	ND	ND	22	781	ND	ND
Drift		W420	2/15/1994 0:00			66	ND	ND	22	841	ND	ND
Drift		W420	6/7/1994 0:00			84	ND	ND	31	1170	ND	ND
Drift		W420	8/29/1994 0:00			80	ND	ND	28	670	ND	ND
Drift		W420	10/11/1994 0:00			79	ND	ND	28	1150	ND	ND
Drift		W420	3/20/1995 0:00			95.2	ND	ND	37.5	864	ND	ND
Drift		W420	5/9/1995 0:00			69.4	1.35	ND	32.1	322	ND	ND
Drift		W420	9/19/1995 0:00			91.2	ND	ND	30.1	914	ND	ND
Drift		W420	10/31/1995 0:00			84.8	ND	ND	27.3	926	ND	ND
Drift		W420	2/26/1996 0:00			84.5	ND	ND	28.3	1200	ND	ND
Drift		W420	4/15/1996 0:00			81.4	ND	ND	31	1210	ND	ND
Drift		W420	7/15/1996 0:00			96	ND	ND	ND	1900	ND	ND
Drift		W420	10/7/1996 0:00			92	ND	ND	35	1300	ND	ND
Drift		W420	2/24/1997 0:00			97.3	ND	ND	31.1	1360	ND	ND
Drift		W420	2/27/1997 0:00			84.5	ND	ND	28.3	1200	ND	ND
Drift		W420	4/15/1997 0:00			91.5	ND	ND	34.1	1240	ND	ND
Drift		W420	5/6/1997 0:00			99	ND	ND	ND	2200	ND	ND
Drift		W420	7/15/1997 0:00			96	ND	ND	ND	1900	ND	ND
Drift		W420	9/8/1997 0:00			86	ND	ND	30	1400	ND	ND
Drift		W420	10/7/1997 0:00			94	ND	ND	35	1300	ND	ND
Drift		W420	1/14/1998 0:00			110	ND	ND	41	1700	ND	ND
Drift		W420	2/10/1998 0:00			120	ND	ND	43	2000	ND	ND
Drift		W420	5/26/1998 0:00			120	ND	ND	ND	1900	ND	ND
Drift		W420	9/8/1998 0:00			140	ND	ND	57	1800	ND	ND
Drift		W420	11/3/1998 0:00			100	ND	ND	34	1600	ND	ND
Drift		W420	3/16/1999 0:00			160	37	<94	<65	2200	<82	ND
Drift		W420	4/19/1999 0:00			240	<15	<47	92	1600	<41	ND
Drift		W420	8/23/1999 0:00			130	<15	<47	49	1300	<41	ND
Drift		W420	11/15/1999 0:00			<36	<15	<47	34	1500	<41	ND
Drift		W420	2/16/2000 0:00			110	<15	<47	43	1300	<41	ND
Drift		W420	2/16/2000 0:00	DUP		110	<15	<47	43	1200	<41	ND
Drift		W420	5/8/2000 0:00			160	<200	<200	61	2900	<200	ND
Drift		W420	5/8/2000 0:00	DUP		110	<200	<200	43	2200	<200	ND
Drift		W420	9/6/2000 0:00			130	2.1	1.1	52	1300	0.56	ND
Drift		W420	9/6/2000 0:00	DUP		220	5	2.3	110	1300	<100	ND
Drift		W420	12/11/2000 0:00			97	<250	<250	35	1600	<250	ND
Drift		W420	12/11/2000 0:00	DUP		99	<250	<250	36	1800	<250	ND
Drift		W420	3/5/2001 0:00			130	2.7	1.2	56	2300	<10	ND
Drift		W420	3/5/2001 0:00	DUP		140	2	0.96	54	2200	0.5	ND
Drift		W420	5/2/2001 0:00			170	2.4	1	66	4900	<10	ND
Drift		W420	5/2/2001 0:00	DUP		170	2.4	1	65	4800	<10	ND
Drift		W420	8/13/2001 0:00			91	1.2	<10	35	1700	<10	ND
Drift		W420	8/13/2001 0:00	DUP		78	<200	<200	26	1500	<200	ND
Drift		W420	10/29/2001 0:00			100	1.5	<2	39	2000	<1.7	ND
Drift		W420	10/29/2001 0:00	DUP		100	<24	<40	34	2500	<34	ND
Drift		W420	3/12/2002 0:00			160	2.1	<2	50	3000	<1.7	ND
Drift		W420	3/12/2002 0:00	DUP		140	2	<2	47	2600	<1.7	ND
Drift		W420	5/6/2002 0:00			130	2.4	<2	58	2700	<1.7	ND

Table 5 Identification of Samples with MDH HRL/HBV Exceedances

			Parameter			Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)_All
			CAS No.			83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
			Limit			400	2,000	300	300	70	200	0.05
			Limit Type			HRL	HRL	HRL	HRL	HRL	HRL	HBV
			Unit			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aquifer		**Sample Location**	**Sample Date**	**Modifier**								
Drift		W420	5/6/2002 0:00	DUP		**130**	**2.4**	<2	**54**	**2800**	<1.7	ND
Drift		W420	9/17/2002 12:30			**130**	**2**	<1.5	**50**	**2500**	<2	ND
Drift		W420	9/17/2002 12:30	DUP		**140**	**2.4**	<1.5	**57**	**2700**	<2	ND
Drift		W420	10/14/2002 11:30			**130**	**1.9**	<1.5	**51**	**2300**	<2	ND
Drift		W420	10/14/2002 11:30	DUP		**130**	**2.2**	<1.5	**52**	**2300**	<2	ND
Drift		W420	3/10/2003 13:30			**140**	**2**	<1	**45**	**2400**	<1	ND
Drift		W420	3/10/2003 13:30	DUP		**130**	**2**	<1	**43**	**2300**	<1	ND
Drift		W420	5/13/2003 12:00			**120**	**2**	<1	**51**	**2600**	<1	ND
Drift		W420	5/13/2003 12:10	DUP		**120**	**2**	<1	**50**	**2700**	<1	ND
Drift		W420	8/12/2003 11:45			**130**	**1.9**	<1	**48**	**1900**	<1	ND
Drift		W420	8/12/2003 11:50	DUP		**130**	**2**	<1	**52**	**2100**	<1	ND
Drift		W420	11/4/2003 0:00			**120**	**2**	<1	**39**	**1900**	<1	ND
Drift		W420	3/2/2004 10:20			**140**	<25	<25	**46**	**2400**	<25	ND
Drift		W420	3/2/2004 10:23	DUP		**140**	<25	<25	**46**	**2600**	<25	ND
Drift		W420	4/27/2004 8:55			**140**	**2.2**	<1	**53**	**2600**	<1	ND
Drift		W420	8/3/2004 8:40			**120**	**1.8**	<1.1	**43**	**2200**	<1.1	ND
Drift		W420	11/15/2004 11:10			**150**	**2.3**	<1.1	**57**	**2800**	<1.1	ND
Drift		W420	11/15/2004 11:15	Dup		**160**	**2.7**	**1.2**	**59**	**3200**	<1.1	ND
Drift		W420	3/8/2005 13:40			**140**	**2.2**	<1.8	**55**	**2700**	<2.1	ND
Drift		W420	9/7/2005 9:30			**180**	**2.4**	<1.8	**68**	**3000**	<2.1	ND
Drift		W420	11/8/2005 8:45			**180**	**2.5**	<1.8	**72**	**2800**	<2.1	ND
Drift		W420	11/8/2005 8:50	DUP		**160**	**2.2**	<1.8	**66**	**2700**	<2.1	ND
Drift		W420	3/3/2006 9:00			**130**	**2.1**	<1.8	**48**	**2500**	<2.1	ND
Drift		W420	3/3/2006 9:10	DUP		**130**	**3.6**	<1.8	**56**	**2200**	<2.1	ND
Drift		W420	5/2/2006 14:30			**150**	**2.2**	<1.8	**60**	**2300**	<2.1	ND
Drift		W420	8/15/2006 14:55			**120**	**2**	<1.8	**49**	**2700**	<2.1	ND
Drift		W420	11/6/2006 11:15			**130**	**2**	<1.8	**50**	**2400**	<2.1	ND
Drift		W420	11/6/2006 11:20	DUP		**130**	**2.2**	<1.8	**52**	**2600**	<2.1	ND
Drift		W420	3/20/2007 9:55			**140**	**2.4**	<1.8	**55**	**2300**	<1.1	ND
Drift		W420	5/7/2007 16:50			**120**	**2.2**	<1.8	**47**	**2100**	<1.1	ND
Drift		W420	8/13/2007 13:00			**150**	**2.3**	**1.3**	**57**	**2100**	<0.37	ND
Drift		W420	8/13/2007 13:35	DUP		**140**	**2.2**	**1.3**	**55**	**2100**	<0.37	ND
Drift		W420	11/15/2007 10:25			**130**	**4.3**	**1.7**	**52**	**2100**	**1.1**	ND
Drift		W420	11/15/2007 10:30	DUP		**150**	<0.42	**1.3**	**56**	**2400**	<0.37	ND
Drift		W420	3/4/2008 13:00			**150**	**2.4**	**1.4**	**58**	**2300**	<0.37	ND
Drift		W420	3/12/2009 13:50			**130**	**2.3**	**1.2**	**48**	**1100**	< 0.37	ND
Drift		W420	3/12/2009 13:55	DUP		**140**	**2.2**	**1.2**	**50**	**580**	< 0.37	ND
Drift		W420	5/5/2009 8:50			**130**	**2.1**	< 2.2	**47**	**2200**	< 2.9	ND
Drift		W420	8/10/2009 12:50			**160**	< 14	< 22	**58**	**2300**	< 29	ND
Drift		W420	3/24/2010 9:10			**140**	**2.7**	**1.6**	**59**	**1900**	< 0.35	ND
Drift		W420	6/1/2010 16:00			**172**	**3.1**	**1.4**	**68.8**	**2330**	**0.74**	ND
Drift		W420	9/15/2010 13:55			**137**	**2.7**	**1**	**50.7**	**1890**	**0.52**	ND
Drift		W420	12/14/2010 10:50			**145**	**2.5**	**1.4**	**53**	**1960**	**0.7**	ND
Drift		W420	3/30/2011 10:20			**120**	**2.7**	<2	**43.3**	**2080**	<2	ND
Drift		W420	3/30/2011 10:25			**117**	**2.4**	<2	**42.8**	**1790**	<2	ND
Drift		W420	6/8/2011 12:15			**130**	**2.1**	**1.3**	**61.2**	**2010**	**0.6**	ND
Drift		W420	9/14/2011 12:15			**136**	**1.8**	**1.1**	**46.2**	**1540**	**0.54**	**0.0014**
Drift		W420	12/13/2011 14:30			**107**	**1.8**	**1.1**	**41.7**	**1190**	**0.57**	ND
Drift		W420	9/18/2012 8:05			**116**	**2.2**	**1.4**	**44.5**	**1750**	**0.68**	**0.04961**
Drift		W439	3/20/1995 0:00			**129**	**30.1**	ND	**25.7**	**1260**	ND	ND
Drift		W439	5/9/1995 0:00			**128**	ND	ND	**22.3**	**1110**	ND	ND
Drift		W439	9/19/1995 0:00			**101**	ND	ND	ND	**1260**	ND	ND
Drift		W439	10/31/1995 0:00			**81.7**	ND	ND	ND	**1220**	ND	ND
Drift		W439	2/26/1996 0:00			**70.9**	ND	ND	ND	**908**	ND	ND
Drift		W439	4/15/1996 0:00			**64.8**	ND	ND	ND	**823**	ND	ND
Drift		W439	7/15/1996 0:00			**79**	ND	ND	ND	**1000**	ND	ND
Drift		W439	10/7/1996 0:00			**78**	ND	ND	ND	**860**	ND	ND
Drift		W439	2/24/1997 0:00			**71.6**	ND	ND	**12.1**	**570**	ND	ND
Drift		W439	2/27/1997 0:00			**70.9**	ND	ND	ND	**908**	ND	ND
Drift		W439	4/15/1997 0:00			**64.8**	ND	ND	ND	**823**	ND	ND
Drift		W439	5/6/1997 0:00			**80**	ND	ND	ND	**1100**	ND	ND
Drift		W439	7/15/1997 0:00			**79**	ND	ND	ND	**1000**	ND	ND
Drift		W439	9/8/1997 0:00			**70**	ND	ND	ND	**920**	ND	ND
Drift		W439	10/7/1997 0:00			**78**	ND	ND	ND	**860**	ND	ND
Drift		W439	1/14/1998 0:00			**62**	ND	ND	ND	**720**	ND	ND
Drift		W439	2/10/1998 0:00			**77**	ND	ND	**11**	**740**	ND	ND
Drift		W439	5/26/1998 0:00			**68**	ND	ND	ND	**660**	ND	ND
Drift		W439	9/8/1998 0:00			**77**	ND	ND	ND	**450**	ND	ND
Drift		W439	11/3/1998 0:00			**52**	ND	ND	ND	**520**	ND	ND
Drift		W439	3/16/1999 0:00			**85**	<15	<47	<32	**790**	<41	ND
Drift		W439	4/19/1999 0:00			**84**	<7.4	<24	<16	**590**	<20	ND
Drift		W439	8/23/1999 0:00			**51**	<7.4	<24	<16	**400**	<20	ND
Drift		W439	11/15/1999 0:00			**63**	<7.4	<24	<16	**590**	<20	ND
Drift		W439	2/14/2000 12:00			**64**	<7.4	<24	<16	**560**	<20	ND

Table 5 Identification of Samples with MDH HRL/HBV Exceedances

			Parameter	Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)_All
			CAS No.	83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
			Limit	400	2,000	300	300	70	200	0.05
			Limit Type	HRL	HRL	HRL	HRL	HRL	HRL	HBV
			Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aquifer	**Sample Location**	**Sample Date**	**Modifier**							
Drift	W439	5/8/2000 0:00		**89**	<100	<100	**13**	**1100**	<100	ND
Drift	W439	9/6/2000 0:00		**130**	<100	<100	**33**	**840**	<100	ND
Drift	W439	12/11/2000 0:00		**58**	<100	<100	**9.8**	**720**	<100	ND
Drift	W439	3/5/2001 0:00		**82**	<50	**0.12**	**14**	**820**	<50	ND
Drift	W439	5/2/2001 0:00		**70**	<10	<10	**10**	**920**	<10	ND
Drift	W439	8/14/2001 0:00		**56**	<100	<100	<100	**610**	<100	ND
Drift	W439	10/29/2001 0:00		**49**	<12	<20	<14	**660**	<17	ND
Drift	W439	3/12/2002 0:00		**64**	<1.2	<2	**10**	**660**	<1.7	ND
Drift	W439	5/14/2002 0:00		**66**	<1.2	<2	**12**	**640**	<1.7	ND
Drift	W439	5/14/2002 0:00	DUP	**63**	<1.2	<2	**12**	**630**	<1.7	ND
Drift	W439	9/23/2002 11:30		**54**	<1.6	<1.5	**9.2**	**430**	<2	ND
Drift	W439	9/23/2002 11:30	DUP	**62**	<1.6	<1.5	**10**	**530**	<2	ND
Drift	W439	5/5/2003 12:00		**58**	<1	<1	**8.4**	**460**	<1	ND
Drift	W439	5/5/2003 12:10	DUP	**61**	<1	<1	**9.1**	**480**	<1	ND
Drift	W439	8/4/2003 8:00		**75**	<1	<1	**12**	**780**	<1	ND
Drift	W439	8/4/2003 8:05	DUP	**80**	<1	<1	**13**	**840**	<1	ND
Drift	W439	4/26/2004 9:55		**73**	<1	<1	**12**	**700**	<1	ND
Drift	W439	4/26/2004 10:00	DUP	**69**	<1	<1	**11**	**640**	<1	ND
Drift	W439	8/2/2004 8:20		**94**	<1.6	<1.5	**17**	**950**	<2	ND
Drift	W439	8/2/2004 8:25	DUP	**92**	<1.6	<1.5	**16**	**1000**	<2	ND
Drift	W439	4/25/2005 10:50	DUP	**69**	<0.5	<1.8	**12**	**790**	<2.1	ND
Drift	W439	9/6/2005 11:15		**74**	<0.5	<1.8	**13**	**740**	<2.1	ND
Drift	W439	5/8/2006 11:40		**66**	<0.5	<1.8	**11**	**780**	<2.1	ND
Drift	W439	8/14/2006 10:50		**63**	<0.5	<1.8	**11**	**570**	<2.1	ND
Drift	W439	5/9/2007 10:10		**57**	<1.8	<1.8	**11**	**490**	<1.1	ND
Drift	W439	8/15/2007 9:40		**59**	<0.42	<0.2	**11**	**520**	<0.37	ND
Drift	W439	5/5/2009 8:35		**54**	< 1.4	< 2.2	**9.7**	**760**	< 2.9	ND
Drift	W439	8/10/2009 13:55		**67**	< 5.5	< 8.8	**11**	**780**	< 12	ND
Drift	W439	9/15/2010 14:05		**56.3**	**0.48**	**0.12**	**9.4**	**619**	**0.061**	ND
Drift	W439	6/10/2011 7:30		**77.5**	**0.48**	**0.13**	**14**	**900**	**0.085**	ND
Drift	W439	9/15/2011 10:20		**42.4**	**0.29**	**0.1**	**7**	**378**	**0.048**	**0.00063**
Drift	W439	6/28/2012 18:45		**66.7**	**0.5**	**0.15**	**9.1**	**663**	**0.076**	ND
Drift	W439	9/20/2012 7:51		**36.9**	**0.39**	**0.11**	**6**	**359**	**0.05**	ND
Drift	W439	9/20/2012 7:51	DUP	**42.2**	**0.42**	**0.12**	**6.4**	**429**	**0.054**	ND
Drift	W6	8/4/1988 0:00		**970**	**210**	**1000**	**840**	**2500**	**700**	**144.7**
Drift	W6	10/27/1988 0:00		**190**	**12**	**23**	**96**	**700**	**15**	**0.17**
Drift	W6	6/23/1989 0:00		**370**	**39**	**200**	**280**	**1000**	**140**	**22.132**
Drift	W9	9/21/2012 8:44		**0.9**	<0.040	<0.040	**0.26**	**125**	<0.040	ND
OPVL	W131	9/18/2012 13:51		**0.54**	**0.12**	**0.49**	**0.36**	**1.6**	**0.31**	**0.09789**
OPVL	W18	10/26/1988 0:00		**8.5**	ND	ND	ND	**98**	**7.8**	ND
OPVL	W27	10/27/1988 0:00		**5.7**	ND	ND	ND	**370**	ND	ND
OPVL	W27	6/23/1989 0:00		**15**	ND	ND	**1.2**	**670**	ND	ND
OPVL	W27	9/30/1997 0:00		**55**	ND	ND	**19**	**130**	ND	ND
OPVL	W27	9/22/1998 0:00		**45**	ND	ND	**14**	**100**	ND	ND
OPVL	W27	5/8/2000 0:00		**44**	<10	<10	**15**	**110**	<10	ND
OPVL	W27	9/27/2010 10:45	DUP	**42.8**	**0.83**	**0.9**	**21.9**	**0.5**	**0.5**	**0.27841**
OPVL	W421	9/21/1988 0:00		**16**	ND	ND	ND	**520**	ND	ND
OPVL	W421	12/28/1988 0:00		**25**	ND	ND	**4.2**	**430**	ND	ND
OPVL	W421	3/29/1989 0:00		**22**	ND	ND	**4.3**	**470**	ND	ND
OPVL	W421	6/29/1989 0:00		**26**	ND	ND	**5.4**	**630**	ND	ND
OPVL	W421	9/27/1989 0:00		**24**	ND	ND	**6**	**350**	ND	ND
OPVL	W421	12/13/1989 0:00		**20**	ND	ND	ND	**530**	ND	ND
OPVL	W421	3/27/1990 0:00		**41**	ND	ND	ND	**850**	ND	ND
OPVL	W421	5/31/1990 0:00		**18**	ND	ND	**4.2**	**430**	ND	ND
OPVL	W421	8/24/1990 0:00		**34**	ND	ND	ND	**920**	ND	ND
OPVL	W421	12/21/1990 0:00		**23**	ND	ND	ND	**750**	ND	ND
OPVL	W421	3/28/1991 0:00		**38**	ND	ND	ND	**890**	ND	ND
OPVL	W421	6/27/1991 0:00		**24**	ND	ND	ND	**950**	ND	**10**
OPVL	W421	9/18/1991 0:00		**33**	ND	ND	**8.9**	**750**	ND	ND
OPVL	W421	10/16/1991 0:00		**33**	ND	ND	**7.8**	**890**	ND	ND
OPVL	W421	2/13/1992 0:00		**30**	ND	ND	**8**	**460**	ND	ND
OPVL	W421	6/22/1992 0:00		**41**	ND	ND	**10**	**930**	ND	ND
OPVL	W421	9/8/1992 0:00		**41**	ND	ND	ND	**1039**	ND	ND
OPVL	W421	11/17/1992 0:00		**46**	ND	ND	**10**	**810**	ND	ND
OPVL	W421	3/23/1993 0:00		**38**	ND	ND	ND	**910**	ND	ND
OPVL	W421	4/27/1993 0:00		**46**	ND	ND	**12**	**1000**	ND	ND
OPVL	W421	8/17/1993 0:00		**35**	ND	ND	ND	**680**	ND	ND
OPVL	W421	10/12/1993 0:00		**39**	ND	ND	**11**	**467**	ND	ND
OPVL	W421	2/15/1994 0:00		**40**	ND	ND	**10**	**620**	ND	ND
OPVL	W421	6/7/1994 0:00		**45**	ND	ND	**14**	**460**	ND	ND
OPVL	W421	8/29/1994 0:00		**40**	**1**	ND	**12**	**290**	ND	ND
OPVL	W421	10/11/1994 0:00		**43**	ND	ND	**12**	**516**	ND	ND
OPVL	W421	3/20/1995 0:00		**42.4**	**6.15**	ND	**14.9**	**236**	ND	ND
OPVL	W421	5/9/1995 0:00		**42.5**	**1.02**	ND	**15.8**	**165**	ND	ND

Table 5 Identification of Samples with MDH HRL/HBV Exceedances

				Parameter		Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)_All
				CAS No.		83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
				Limit		400	2,000	300	300	70	200	0.05
				Limit Type		HRL	HRL	HRL	HRL	HRL	HRL	HBV
				Unit		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aquifer		**Sample Location**	**Sample Date**	**Modifier**								
OPVL		W421	10/31/1995 0:00			**40**	ND	ND	**12.1**	**424**	ND	ND
OPVL		W421	2/26/1996 0:00			**33.6**	ND	ND	**11**	**352**	ND	ND
OPVL		W421	4/15/1996 0:00			**34.6**	ND	ND	**13.2**	**332**	ND	ND
OPVL		W421	7/15/1996 0:00			**44**	ND	ND	**14**	**480**	ND	ND
OPVL		W421	10/7/1996 0:00			**45**	ND	ND	**14**	**440**	ND	ND
OPVL		W421	2/24/1997 0:00			**45.2**	ND	ND	**15.6**	**309**	ND	ND
OPVL		W421	2/27/1997 0:00			**33.6**	ND	ND	**11**	**352**	ND	ND
OPVL		W421	4/15/1997 0:00			**34.6**	ND	ND	**13.2**	**332**	ND	ND
OPVL		W421	5/6/1997 0:00			**45**	ND	ND	**11**	**450**	ND	ND
OPVL		W421	7/15/1997 0:00			**44**	ND	ND	**14**	**480**	ND	ND
OPVL		W421	9/8/1997 0:00			**38**	ND	ND	**12**	**380**	ND	ND
OPVL		W421	10/7/1997 0:00			**45**	ND	ND	**14**	**440**	ND	ND
OPVL		W421	1/14/1998 0:00			**46**	ND	ND	**16**	**400**	ND	ND
OPVL		W421	2/10/1998 0:00			**59**	ND	ND	**17**	**450**	ND	ND
OPVL		W421	5/26/1998 0:00			**50**	ND	ND	**16**	**270**	ND	ND
OPVL		W421	9/8/1998 0:00			**37**	ND	ND	**12**	**150**	ND	ND
OPVL		W421	11/3/1998 0:00			**41**	ND	ND	**12**	**220**	ND	ND
OPVL		W421	3/16/1999 0:00			**37**	<15	<47	<32	**180**	<41	ND
OPVL		W421	4/19/1999 0:00			**59**	<3	<9.4	**21**	**170**	<8.2	ND
OPVL		W421	8/23/1999 0:00			**33**	<1.5	<4.7	**13**	**120**	<4.1	ND
OPVL		W421	11/15/1999 0:00			**41**	<3	<9.4	**12**	**170**	<8.2	ND
OPVL		W421	2/14/2000 12:00			**39**	**2.1**	<4.7	**15**	**120**	<4.1	ND
OPVL		W421	5/8/2000 0:00			**55**	**1.4**	**1**	**20**	**180**	**0.48**	ND
OPVL		W421	9/6/2000 0:00			**89**	**16**	**60**	**68**	**110**	**45**	**10.3958**
OPVL		W421	12/11/2000 0:00			**41**	**1.2**	**3**	**14**	**100**	**2**	ND
OPVL		W421	3/5/2001 0:00			**42**	**2.9**	**11**	**16**	**71**	**7.6**	**1.558**
OPVL		W421	5/2/2001 0:00			**53**	**1.9**	**5.8**	**20**	**290**	**4.2**	**1.874**
OPVL		W421	8/13/2001 0:00			**55**	**8.5**	**40**	**32**	**26**	**27**	**6.681**
OPVL		W421	10/29/2001 0:00			**35**	**4.4**	**45**	**13**	<1.4	**33**	**8.095**
OPVL		W421	3/12/2002 0:00			**53**	**3.4**	**14**	**22**	**120**	**9.5**	**0.614**
OPVL		W421	5/6/2002 0:00			**44**	**4.6**	**17**	**25**	**75**	**12**	**0.346**
OPVL		W421	9/17/2002 12:00			**59**	**2**	**4.8**	**26**	**120**	**3.1**	ND
OPVL		W421	10/24/2002 15:30			**54**	**3.4**	**14**	**24**	**110**	**9.5**	**0.537**
OPVL		W421	3/10/2003 13:50			**84**	**33**	**380**	**44**	**37**	**270**	**100.824**
OPVL		W421	5/13/2003 12:40			**160**	**59**	**340**	**150**	**140**	**230**	**70.1**
OPVL		W421	8/12/2003 12:05			**63**	**4.3**	**12**	**30**	**140**	**7.7**	**1.335**
OPVL		W421	11/4/2003 0:00			**340**	**150**	**850**	**270**	**220**	**630**	**159.86**
OPVL		W421	3/2/2004 10:45			**74**	**6.5**	**32**	**33**	**130**	**23**	**5.457**
OPVL		W421	5/3/2004 9:05			**68**	**3.2**	**8.1**	**28**	**140**	**5.2**	ND
OPVL		W421	5/3/2004 9:10	DUP		**67**	**3.3**	**8.1**	**28**	**140**	**5.1**	ND
OPVL		W421	8/9/2004 8:00			**94**	**8.6**	**25**	**47**	**140**	**17**	**2.592**
OPVL		W421	8/9/2004 8:05	DUP		**76**	**6.7**	**22**	**34**	**160**	**15**	**2.176**
OPVL		W421	11/15/2004 11:40			**100**	**9.3**	**31**	**51**	**280**	**22**	**3.95**
OPVL		W421	3/8/2005 13:50			**72**	**4.2**	**17**	**29**	**58**	**12**	**1.864**
OPVL		W421	11/8/2005 9:15			**67**	**4**	**16**	**31**	**21**	**10**	**2.06**
OPVL		W421	3/3/2006 9:05			**68**	**3.2**	**10**	**28**	**180**	**6.7**	ND
OPVL		W421	5/3/2006 16:10			**69**	**3.9**	**12**	**29**	**110**	**7.7**	ND
OPVL		W421	8/16/2006 13:10			**75**	**7.1**	**20**	**39**	**75**	**13**	**0.22**
OPVL		W421	11/6/2006 11:50			**76**	**5.2**	**16**	**35**	**110**	**10**	**0.18**
OPVL		W421	3/20/2007 10:00			**80**	**5.5**	**15**	**37**	**96**	**9.6**	**0.17**
OPVL		W421	3/20/2007 10:05	DUP		**77**	**7**	**39**	**36**	**50**	**27**	**7.668**
OPVL		W421	5/8/2007 8:50			**76**	**7.5**	**25**	**38**	**80**	**17**	**1.973**
OPVL		W421	8/14/2007 11:50			**98**	**9.8**	**35**	**50**	**130**	**25**	**4.243**
OPVL		W421	11/15/2007 10:45			**69**	**4**	**14**	**29**	**200**	**10**	**1.637**
OPVL		W421	3/4/2008 13:05			**95**	**11**	**62**	**48**	**150**	**43**	**18.716**
OPVL		W421	3/4/2008 13:10	DUP		**90**	**8.8**	**58**	**43**	**120**	**37**	**25.708**
OPVL		W421	5/7/2009 11:45			**70**	**5.4**	**21**	**32**	**67**	**15**	**3.242**
OPVL		W421	8/13/2009 11:10			**130**	**26**	**120**	**78**	**220**	**91**	**31.08**
OPVL		W421	3/24/2010 9:30			**250**	**83**	**390**	**210**	**460**	**260**	**78.966**
OPVL		W421	3/24/2010 9:35	DUP		**220**	**62**	**270**	**170**	**420**	**200**	**61.634**
OPVL		W421	6/1/2010 16:20			**126**	**15**	**63.3**	**64.4**	**376**	**49.4**	**24.358**
OPVL		W421	9/22/2010 11:15			**205**	**49.8**	**249**	**140**	**414**	**175**	**52.652**
OPVL		W421	9/22/2010 11:15	DUP		**138**	**22**	**96.9**	**80.7**	**342**	**68.8**	**20.024**
OPVL		W421	12/14/2010 11:00			**145**	**22.5**	**83.9**	**85.3**	**415**	**64.3**	**16.262**
OPVL		W421	3/30/2011 10:40			**118**	**19.5**	**68.5**	**74.8**	**260**	**50.1**	**14.474**
OPVL		W421	6/8/2011 12:20			**120**	**6.7**	**22.3**	**56.3**	**312**	**12.6**	**1.2382**
OPVL		W421	9/14/2011 12:20			**303**	**56.2**	**171**	**188**	**880**	**120**	**39.032**
OPVL		W421	9/14/2011 12:25			**288**	**47.6**	**141**	**170**	**956**	**101**	**31.009**
OPVL		W421	12/13/2011 14:40	DUP		**359**	**96.8**	**449**	**259**	**1000**	**323**	**104.015**
OPVL		W421	12/13/2011 14:50			**299**	**123**	**331**	**219**	**1020**	**233**	**85.879**
OPVL		W421	9/18/2012 8:05			**127**	**23.7**	**77.9**	**78.4**	**474**	**48.2**	**15.225**
OPVL		W421	9/18/2012 8:05	DUP		**180**	**43.5**	**150**	**122**	**695**	**97.7**	**34.98**
OPVL		W426	8/3/1988 0:00			**97**	**1.3**	ND	**46**	**420**	ND	ND
OPVL		W426	6/23/1989 0:00			**15**	ND	ND	**13**	**180**	ND	ND

Table 6 List of Wells to Assess Contaminant Spreading

2013 Sampling Plan, St. Peter Aquifer Wells: W24, W33R, W409, W410, W411, W412, W129, W408, and W414 (EPA well MN Unique No. 763378) Additional St. Peter Aquifer Wells: W133, W14, W21
2013 Sampling Plan, Platteville Aquifer Wells: W20, W27, W130, W131, W143, W421, W424, W426, W428, W434, W437, and W438 Additional Platteville Aquifer Wells: W100, W120, W132, W429, W431, W433, W435, W415 (EPA well MN Unique No. 763377), W417 (EPA well MN Unique No. 763379), new Platteville sentry well
2013 Sampling Plan Drift Aquifer Wells: W420, P309, W439, P109, P307, P308, P310, and W422 Additional Drift Aquifer Wells: P304, W2, W10, W423, W425, W136, W12, P313, W427, W416 (EPA well MN Unique No. 763376), W418 (EPA well MN Unique No. 763380), new Drift sentry well

Table 5 Identification of Samples with MDH HRL/HBV Exceedances

					Parameter	Acenaphthene	Anthracene	Fluoranthene	Fluorene	Naphthalene	Pyrene	BaP_Equivalents(Sum)_All
					CAS No.	83-32-9	120-12-7	206-44-0	86-73-7	91-20-3	129-00-0	Not Assigned
					Limit	400	2,000	300	300	70	200	0.05
					Limit Type	HRL	HRL	HRL	HRL	HRL	HRL	HBV
					Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aquifer		**Sample Location**	**Sample Date**	**Modifier**								
OPVL		W426	9/22/1998 0:00			**240**	**17**	**12**	**140**	**230**	**6.1**	ND
OPVL		W426	4/18/1999 0:00			**89**	**5.8**	**5.1**	**59**	**89**	<4.1	ND
OPVL		W434	9/6/2000 0:00			**1.1**	<10	<10	<10	<10	<10	**0.27**
OPVL		W437	2/11/1992 0:00			**22**	ND	ND	ND	**2100**	ND	ND
OPVL		W437	5/2/2001 15:30			**230**	<10	<10	**54**	**4900**	<10	ND
OPVL		W437	8/13/2001 14:00			**180**	<500	<500	**50**	**4300**	<500	ND
OPVL		W437	5/13/2002 16:40			**150**	<1.2	<2	**52**	**4200**	<1.7	ND
OPVL		W437	9/24/2002 15:30			**180**	<1.6	<1.5	**58**	**4100**	<2	ND
OPVL		W437	8/11/2003 9:55			**190**	<1	<1	**68**	**4800**	<1	ND
OPVL		W437	5/3/2004 10:00			**190**	<1	<1	**65**	**5000**	<1	ND
OPVL		W437	8/9/2004 11:45			**150**	<1.6	<1.1	**47**	**3600**	<1.1	ND
OPVL		W437	9/9/2005 15:30			**170**	<0.5	<1.8	**70**	**4600**	<2.1	ND
OPVL		W437	5/2/2006 9:45			**130**	<0.5	<1.8	**45**	**3300**	<2.1	ND
OPVL		W437	5/2/2006 9:50	DUP		**140**	<0.5	<1.8	**48**	**3100**	<2.1	ND
OPVL		W437	8/15/2006 16:00			**140**	**2.9**	<1.8	**55**	**4400**	<2.1	ND
OPVL		W437	8/15/2006 16:05	DUP		**140**	<0.5	<1.8	**51**	**4300**	<2.1	ND
OPVL		W437	5/7/2007 12:55			**110**	<1.8	<1.8	**50**	**2900**	<1.1	ND
OPVL		W437	8/13/2007 13:50			**140**	<0.42	<0.2	**53**	**2800**	<0.37	ND
OPVL		W437	5/12/2008 15:20			**120**	<0.42	<0.2	**47**	**1900**	<0.37	ND
OPVL		W437	8/21/2008 15:30			**150**	<0.42	<0.2	**54**	**2600**	<0.37	ND
OPVL		W437	5/8/2009 15:00			**96**	< 1.4	< 2.2	**43**	**1900**	< 2.9	ND
OPVL		W437	8/18/2009 15:40			**140**	< 1.4	< 2.2	**49**	**2000**	< 2.9	ND
OPVL		W437	6/7/2010 12:10			**111**	**1.8**	<0.0040	**41.6**	**1090**	<0.0060	ND
OPVL		W437	9/27/2010 14:10			**113**	<0.020	<0.020	**38.1**	**1360**	<0.020	ND
OPVL		W437	6/8/2011 14:50			**41.6**	**0.66**	<0.02	**13.8**	**850**	<0.02	ND
OPVL		W437	9/25/2012 11:50			**47.3**	**0.73**	<0.042	**12.9**	**633**	<0.042	ND
OPVL		W438	5/1/2001 9:35			**0.026**	**0.017**	**0.13**	**0.0067**	**0.079**	**0.14**	**0.13231**
OPVL		W438	9/4/2001 13:00			**0.035**	**0.053**	**0.094**	<0.0056	**0.35**	**0.093**	**0.17584**
OSTP		W409	4/16/1996 0:00			**75.3**	ND	ND	**38**	**142**	ND	ND
OSTP		W409	5/8/2000 0:00			**120**	<20	**4**	**55**	**170**	**1.7**	ND
OSTP		W409	9/6/2000 0:00			**56**	**1.3**	**0.82**	**27**	**73**	**0.43**	**0.0062**
OSTP		W410	5/8/2000 0:00			**6.5**	**0.42**	**2.6**	**4.4**	**11**	**2.6**	**0.0644**
PCJ		W23	5/9/1995 0:00			**14.6**	**2.32**	**7.45**	**10.8**	**35.4**	**7.48**	**0.2141**
PCJ		W23	4/30/2001 0:00			**5.5**	**0.28**	**1.2**	**2**	**7.3**	**1.2**	**0.06433**
PCJ		W23	4/30/2001 0:00	DUP		**2.2**	**0.23**	**1.1**	**1.8**	**3.4**	**0.99**	**0.06289**
PCJ		W23	6/4/2002 0:00			**5.3**	**0.4**	**1.8**	**3.1**	**6.7**	**1.7**	**0.0685**
PCJ		W23	6/4/2002 0:00	DUP		**4.5**	**0.35**	**1.5**	**2.6**	**5.8**	**1.4**	**0.0439**
PCJ		W23	9/2/2003 12:10			**4.5**	**0.24**	**1.6**	**2.9**	**4.5**	**1.6**	**0.062522**
PCJ		W23	12/14/2010 13:25			**3.4**	**0.18**	**1.4**	**2.3**	**2**	**1.3**	**0.0681**
PCJ		W23	12/14/2010 13:30	DUP		**3.7**	**0.19**	**1.4**	**2.5**	**2.3**	**1.3**	**0.0713**
PCJ		W403	5/14/2007 12:50			**0.0043**	**0.011**	**0.079**	**0.0036**	**0.011**	**0.079**	**0.07881**
PCJ		W403	5/1/2008 16:15			**0.0081**	**0.028**	**0.22**	**0.0084**	**0.016**	**0.22**	**0.26276**
PCJ		W403	5/6/2009 17:30			**0.0032**	**0.011**	**0.1**	**0.0035**	**0.0055**	**0.097**	**0.11545**
PCJ		W403	5/6/2009 17:35	DUP		**0.0023**	**0.0081**	**0.066**	**0.0026**	**0.0048**	**0.064**	**0.071058**

Notes:

ug/L = micrograms-per-liter

-- = Analyte not sampled

ND = Analyte not detected above the laboratory method detection limit

HRL = Health Risk Limit (Mn Department of Health)

HBV = Health Based Value (Mn Department of Health)

Bold = Analyte detected above the laboratory's method detection limit

Shaded Cell = Analyte detected above the HRL/HBV

BaP Equivalents (Sum)_All = Total Benzo(a)pyrene (BaP) Equivalents (MPCA c-w3-01.xls).
This sum includes the results of all of the BaP equivalent parameters inlcuded in
the list of parameterd sampled for a given sample location and date.

Table 7 2012 Water Elevation Data

WELL	DATE	MP Elevation	DEPTH TO WATER	WL Elev
St. Peter				
W14	9/21/2012	891.49	16.12	875.37
W24		893.19	NM	NM
W33R	9/24/2012	893.99	28.00	865.99
W122	9/17/2012	918.58	63.17	855.41
W129	9/17/2012	916.33	49.86	866.47
W408	9/25/2012	923.53	52.20	871.33
W409	9/24/2012	923.61	55.89	867.72
W410		908.04	NM	NM
W411	9/21/2012	896.25	34.40	861.85
W412	9/21/2012	915.17	50.89	864.28
W414	9/24/2012	921.29	56.98	864.31
W414	12/6/2012	921.29	55.70	865.59
Platteville				
W18	9/21/2012	893.33	10.55	882.78
W20	9/26/2012	895.83	18.60	877.23
W22	9/20/2012	897.06	12.34	884.72
W27	9/24/2012	910.47	27.88	882.59
W101	9/18/2012	918.03	40.22	877.81
W121	9/20/2012	922.85	48.40	874.45
W130	9/21/2012	894.83	23.50	871.33
W131	9/18/2012	919.27	38.61	880.66
W143	9/20/2012	905.31	24.63	880.68
W421		895.86	NM	NM
W424	9/24/2012	917.57	35.12	882.45
W426	9/20/2012	923.95	41.57	882.38
W428	9/20/2012	919.4	38.84	880.56
W437	9/26/2012	913.18	30.88	882.30
W438	9/25/2012	921.12	40.60	880.52
W415	12/6/2012	920.16	45.30	874.86
Drift				
P109	9/26/2012	895.11	13.62	881.49
P112	9/26/2012	903.8	23.40	880.40
P307	9/26/2012	913.1	33.14	879.96
P308	9/26/2012	923.29	41.63	881.66
P309	9/25/2012	925.16	43.72	881.44
P310	9/25/2012	921.48	40.88	880.60
P312	9/25/2012	919.45	41.47	877.98
W2	9/25/2012	897.96	12.00	885.96
W9	9/21/2012	891.21	9.30	881.91
W10	9/25/2012	892.03	9.85	882.18
W15	9/25/2012	894.47	10.58	883.89
W117	9/18/2012	917.75	39.45	878.30
W128	9/20/2012	922.89	47.84	875.05
W136	9/18/2012	919.17	38.15	881.02
W420		895.88		
W427	9/20/2012	919.4	38.42	880.98
W439		924.9		
W416	12/6/2012	920.21	44.79	875.42

Figures

18

[redacted]

Map adapted from ESRI Basemap: World Street Map.

Explanation

- Drift
- Platteville
- St. Peter
- Site Outline

N
W E
S

0 1,500 Feet

1 inch = 1,500 feet

Site Location

WELL LOCATION MAP (DRIFT/OPVL/OSTP)

Reilly Site

St. Louis Park, Minnesota

Summit Envirosolutions ®

Figure 1

File:20121029_SampleLocs_Working
Summit Proj. No.: 0987-0009
Plot Date: 10-29-12
Arc Operator: PRB
Reviewed by: BMG

[redacted]

Map adapted from ESRI Basemap: World Street Map.

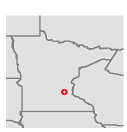
Explanation

- CJDN; OPDC; PCJ
- CMSH
- IGV
- siteoutline

N
W E
S

0 3,500 Feet

1 inch = 3,500 feet



Site Location

WELL LOCATION MAP
(PCJ/MTS/IGV)

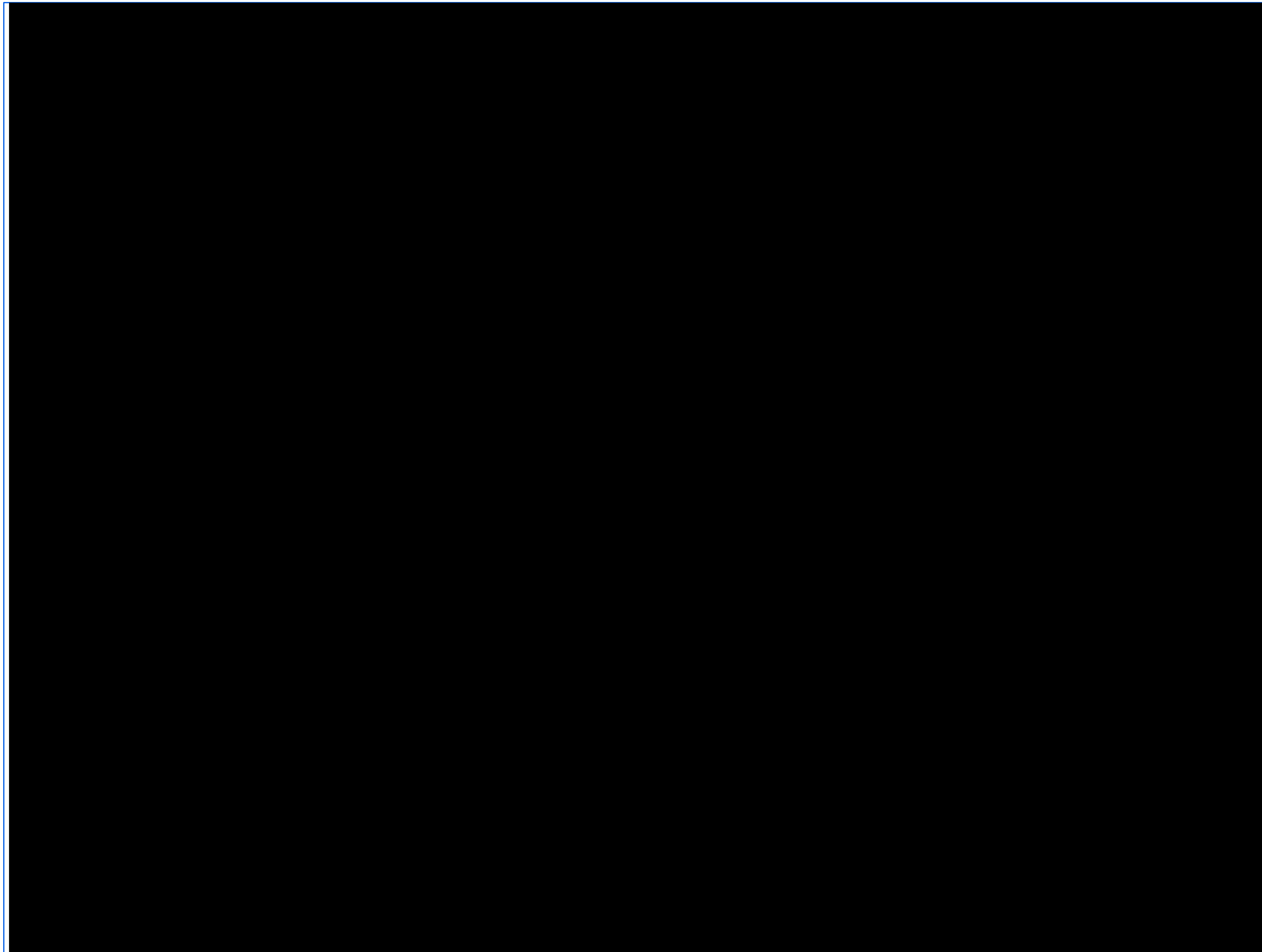
Reilly Site

St. Louis Park, Minnesota

Summit Envirosolutions

Figure 2

File:20121029_PCJ_MTS_IGV
Summit Proj. No.: 0987-0009
Plot Date: 10-30-12
Arc Operator: PRB
Reviewed by: BMG



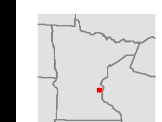
Legend

Sample Location (Result ug/L)

- ND
- 0.000001 - 1950

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)



Site Location

N
W E
S

0 1,200
Feet

1 inch = 1,200 feet

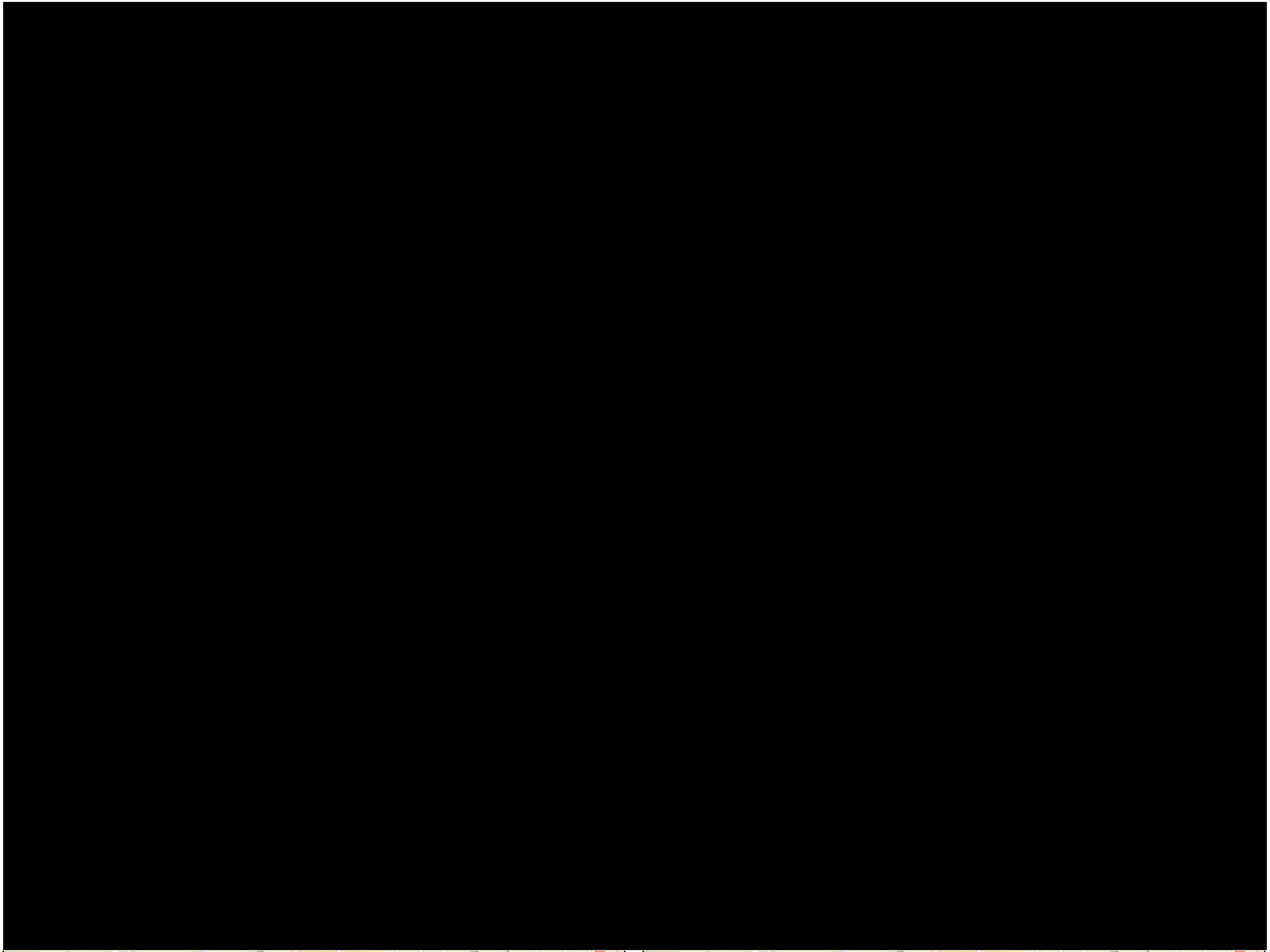
GROUNDWATER CONCENTRATIONS
DRIFT AQUIFER
Max of Results from September 2012

Reilly Site
St. Louis Park, Minnesota

Figure 3

File: 20121105_Landscape_11x17.mxd
Summit Proj. No.: 0987-0009
Plot Date: 11-05-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions



Map adapted from ESRI, World Street Map.

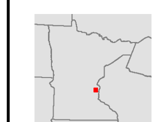
Legend

Sample Locations (Result ug/L)

- ND
- 0.000001 - 1708

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)



Site Location

N W E S

0 1,200 Feet

1 inch = 1,200 feet

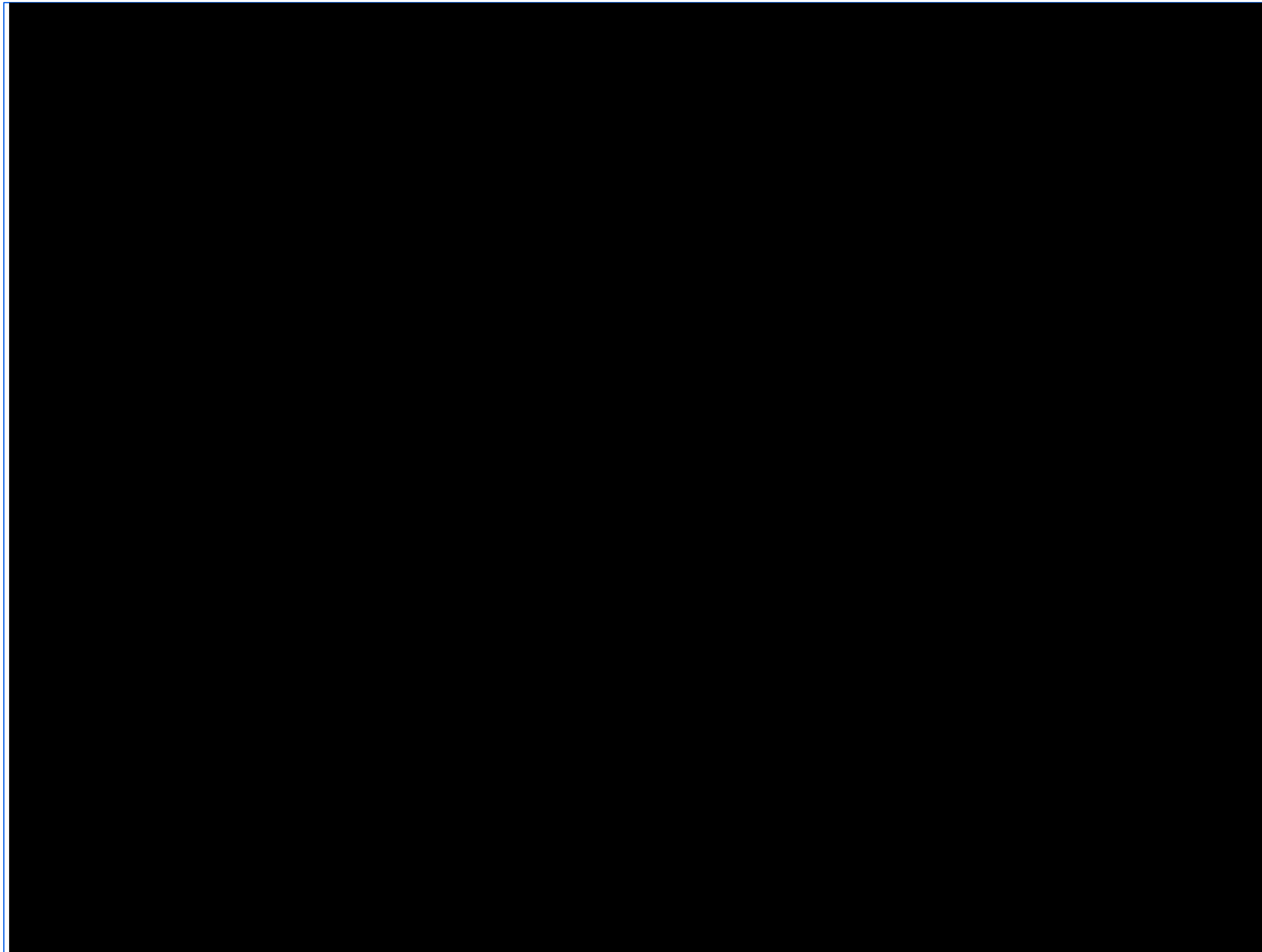
GROUNDWATER CONCENTRATIONS
OPVL AQUIFER
Max of Results from September 2012

Reilly Site
St. Louis Park, Minnesota

Figure 4

File: 20121105_092012_OPVL_GWCx4
Summit Proj. No.: 0987-0009
Plot Date: 11-05-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions ®



Map adapted from ESRI, World Street Map.

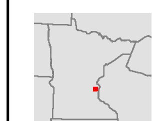
Legend

Sample Location (Result ug/L)

- ND
- 0.000001 - 33

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)



Site Location

0 1,200 Feet

1 inch = 1,700 feet

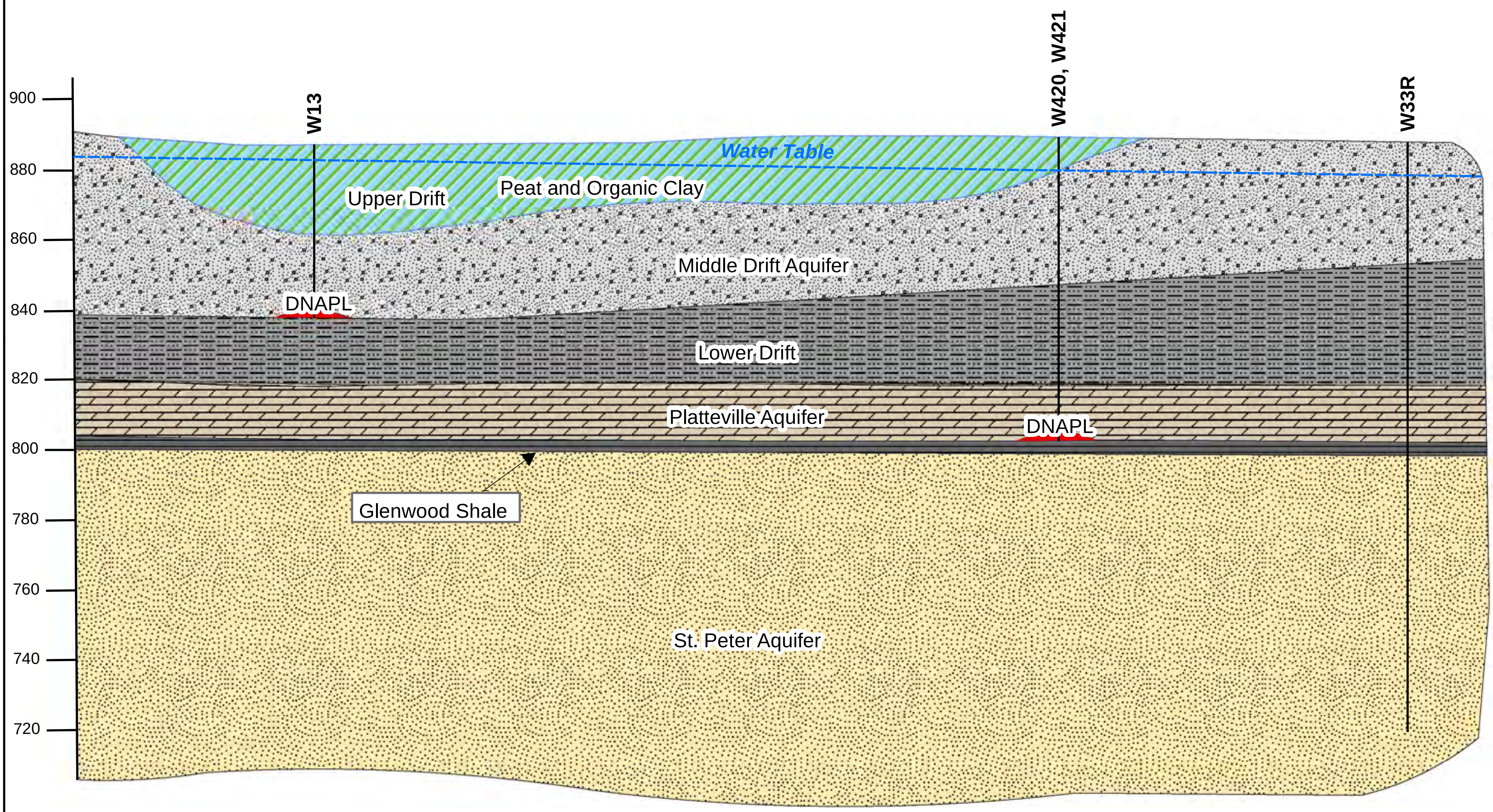
GROUNDWATER CONCENTRATIONS
OSTP AQUIFER
Max of Results from September 2012

Reilly Site
St. Louis Park, Minnesota

Figure 5

File: 20121105_092012_OSTP_GWCx4
Summit Proj. No.: 0987-0009
Plot Date: 11-05-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions



900
880
860
840
820
800
780
760
740
720
W13
W420, W421
W33R
Water Table
Upper Drift
Peat and Organic Clay
Middle Drift Aquifer
DNAPL
Lower Drift
Platteville Aquifer
DNAPL
Glenwood Shale
St. Peter Aquifer

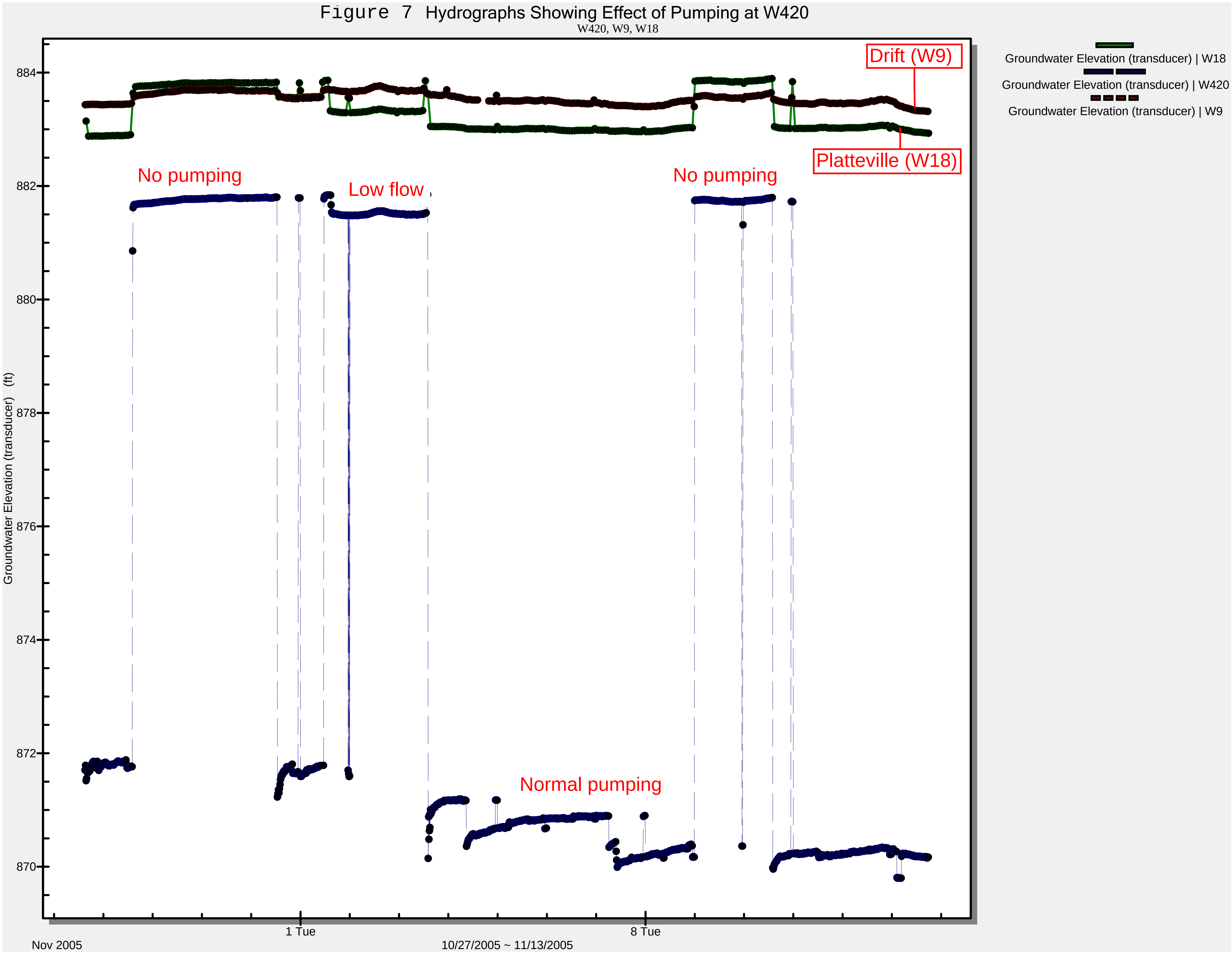


Figure 7 Hydrographs Showing Effect of Pumping at W420
W420, W9, W18
Groundwater Elevation (transducer) | W18
Groundwater Elevation (transducer) | W420
Groundwater Elevation (transducer) | W9
Drift (W9)
Platteville (W18)
No pumping
Low flow
No pumping
Normal pumping
Groundwater Elevation (transducer) (ft)
884
882
880
878
876
874
872
870
1 Tue
8 Tue
Nov 2005
10/27/2005 ~ 11/13/2005

Figure 8.

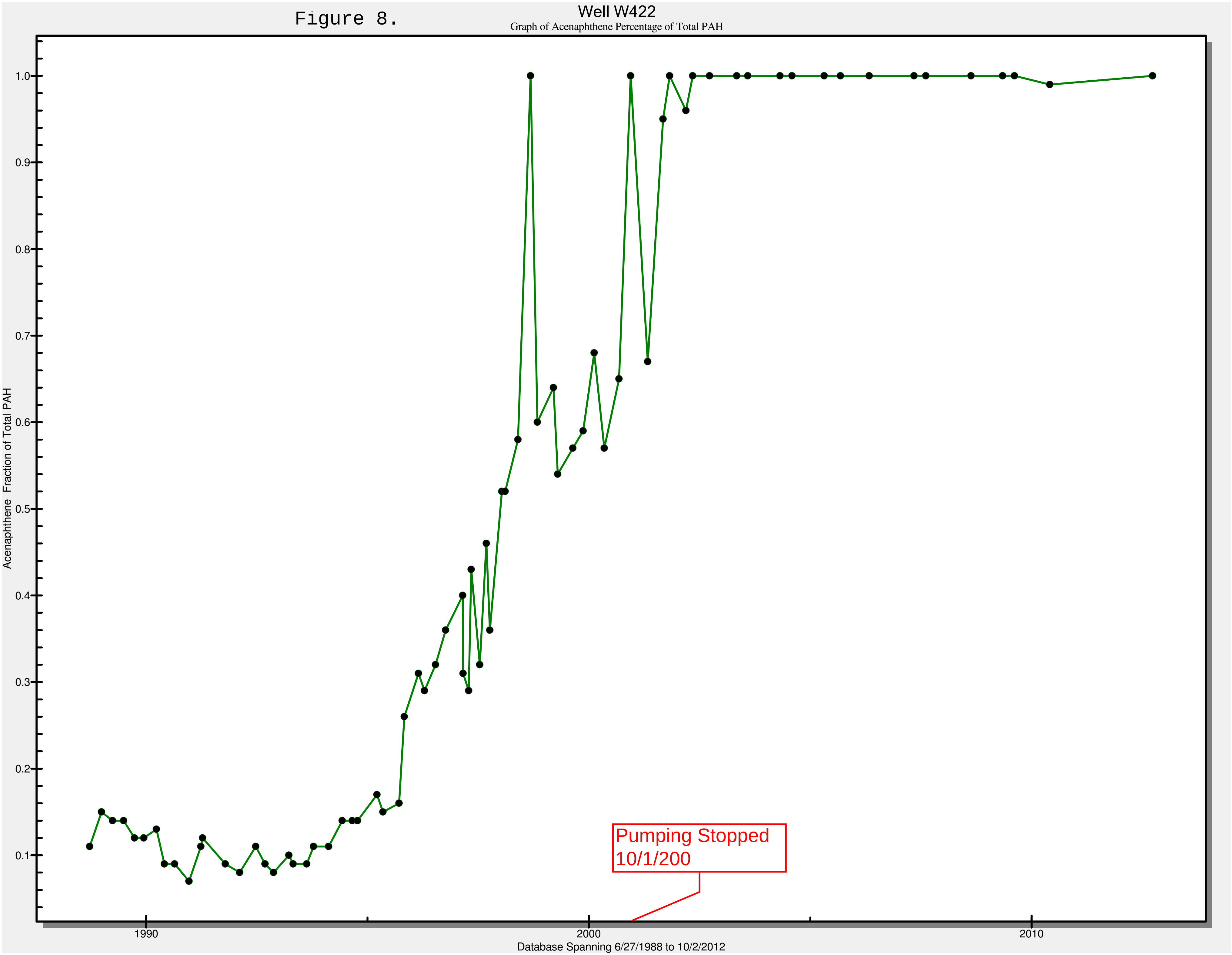
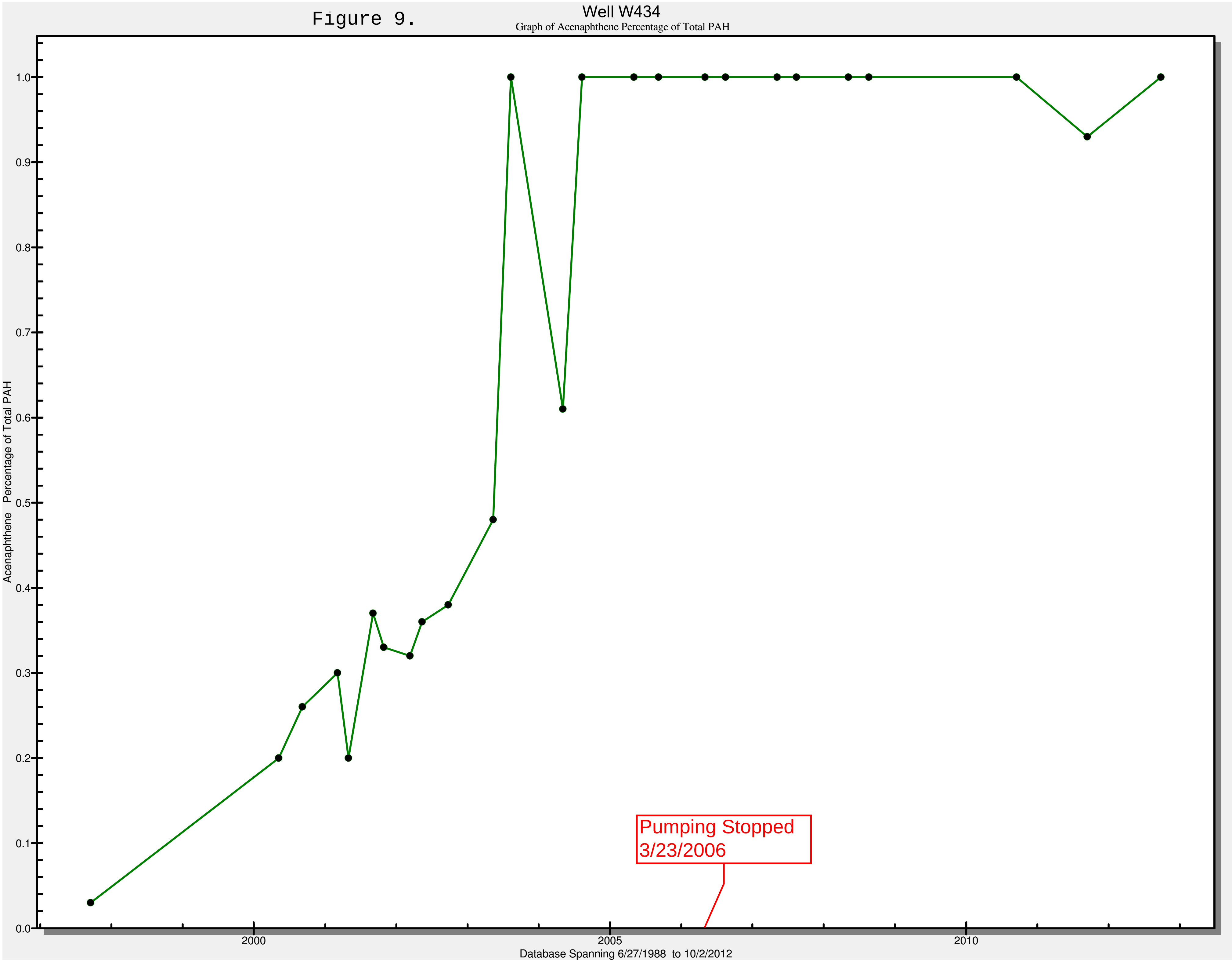
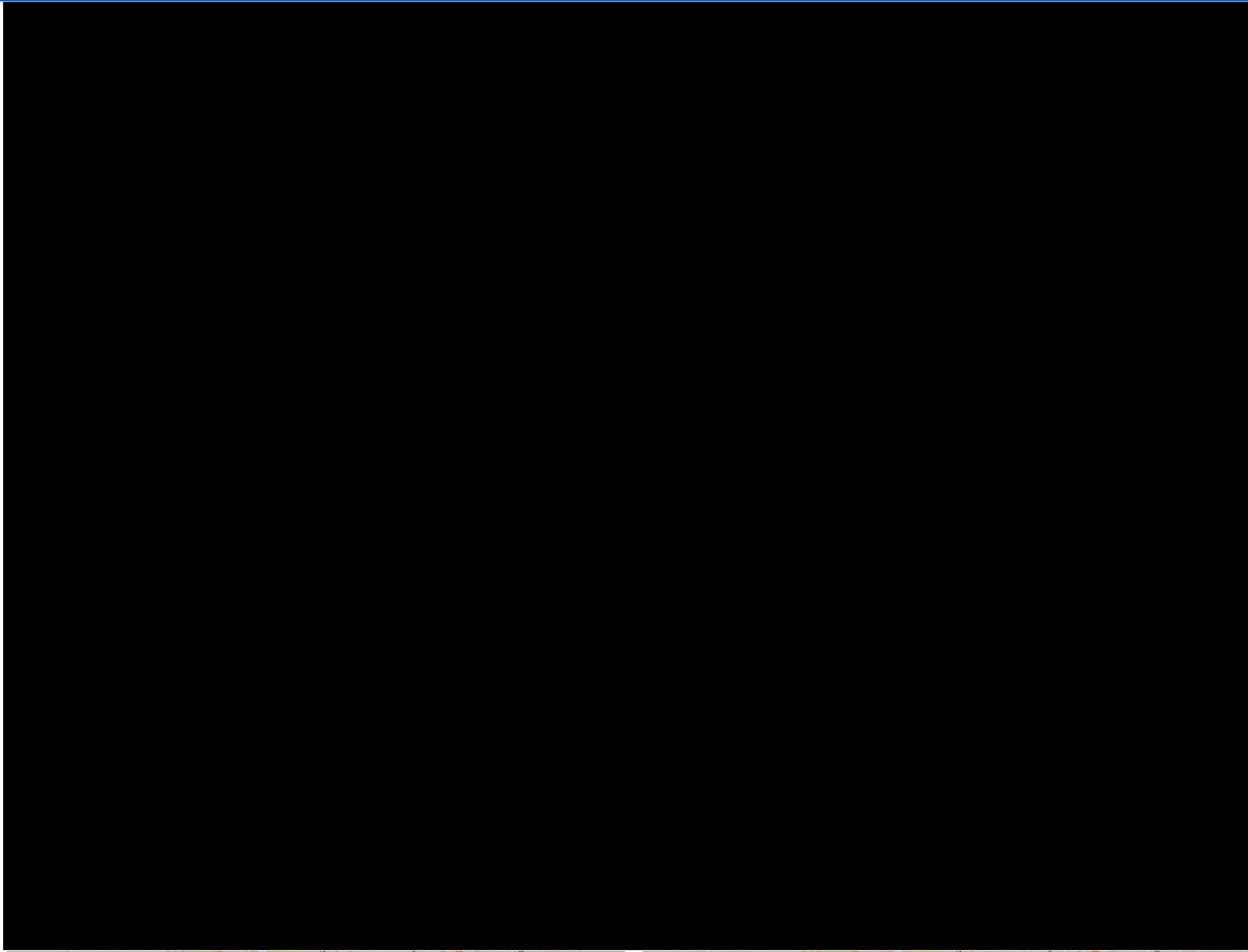

Well W422
Graph of Acenaphthene Percentage of Total PAH
Acenaphthene Fraction of Total PAH
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Pumping Stopped
10/1/200
1990
2000
2010
Database Spanning 6/27/1988 to 10/2/2012

Figure 9.


Well W434
Graph of Acenaphthene Percentage of Total PAH
Acenaphthene Percentage of Total PAH
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2000
2005
2010
Database Spanning 6/27/1988 to 10/2/2012
Pumping Stopped
3/23/2006

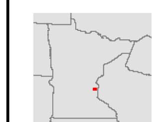


Explanation

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)

421 (884) Sample Location Total PAH (ug/L)


Site Location

N E S W

0 1,800 Feet

1 inch = 1,800 feet

HISTORIC AND RECENT ISOCONCENTRATION MAPS FOR THE DRIFT AQUIFER (1988,1994,2004,2012)

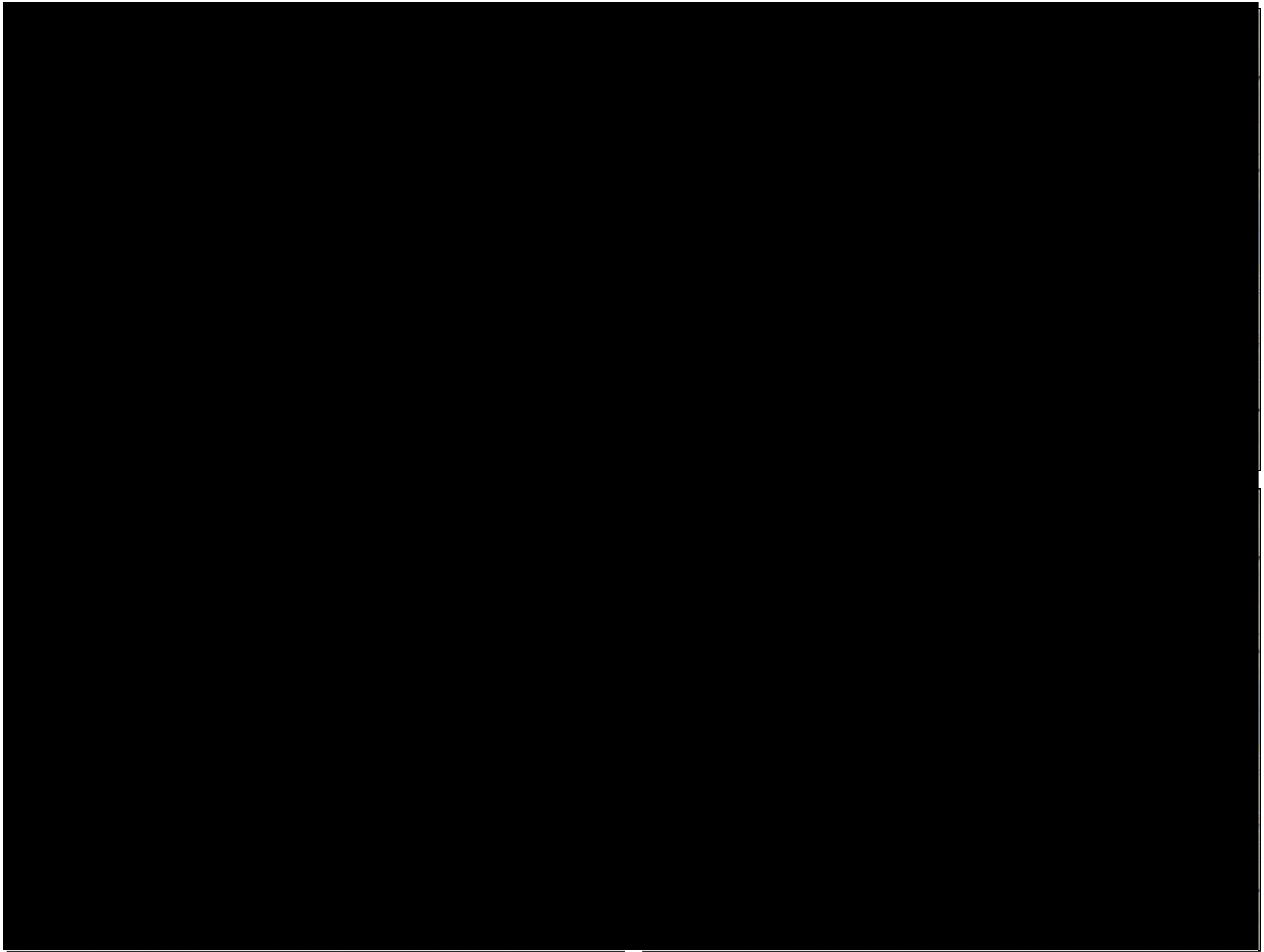
Reilly Site
St. Louis Park, Minnesota

Figure 10

File: 20121119_DRIFT_PAHSum31
Summit Proj. No.: 0987-0009
Plot Date: 11-28-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions®

Map adapted from ESRI, World Street Map.

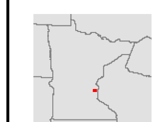


Explanation

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)

421 (884) — Sample Location Total PAH (ug/L)



Site Location

N W E S

0 1,800 Feet

1 inch = 1,800 feet

HISTORIC AND RECENT ISOCONCENTRATION MAPS FOR THE PLATTEVILLE AQUIFER (1988,1996,2004,2012)

Reilly Site
St. Louis Park, Minnesota

Figure 11

File: 20121119_OPVL_PAHSum31
Summit Proj. No.: 0987-0009
Plot Date: 12-10-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions®

Map adapted from ESRI, World Street Map.

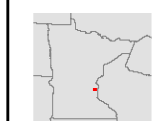
Map adapted from ESRI, World Street Map.

Explanation

Interpolated Grid of Concentrations

- ND - 0.28 (ug/L)
- 0.28 - 70 (ug/L)
- 70 - 4,000 (ug/L)

421 (884) Sample Location Total PAH (ug/L)



Site Location

N W E S

0 1,800 Feet

1 inch = 1,800 feet

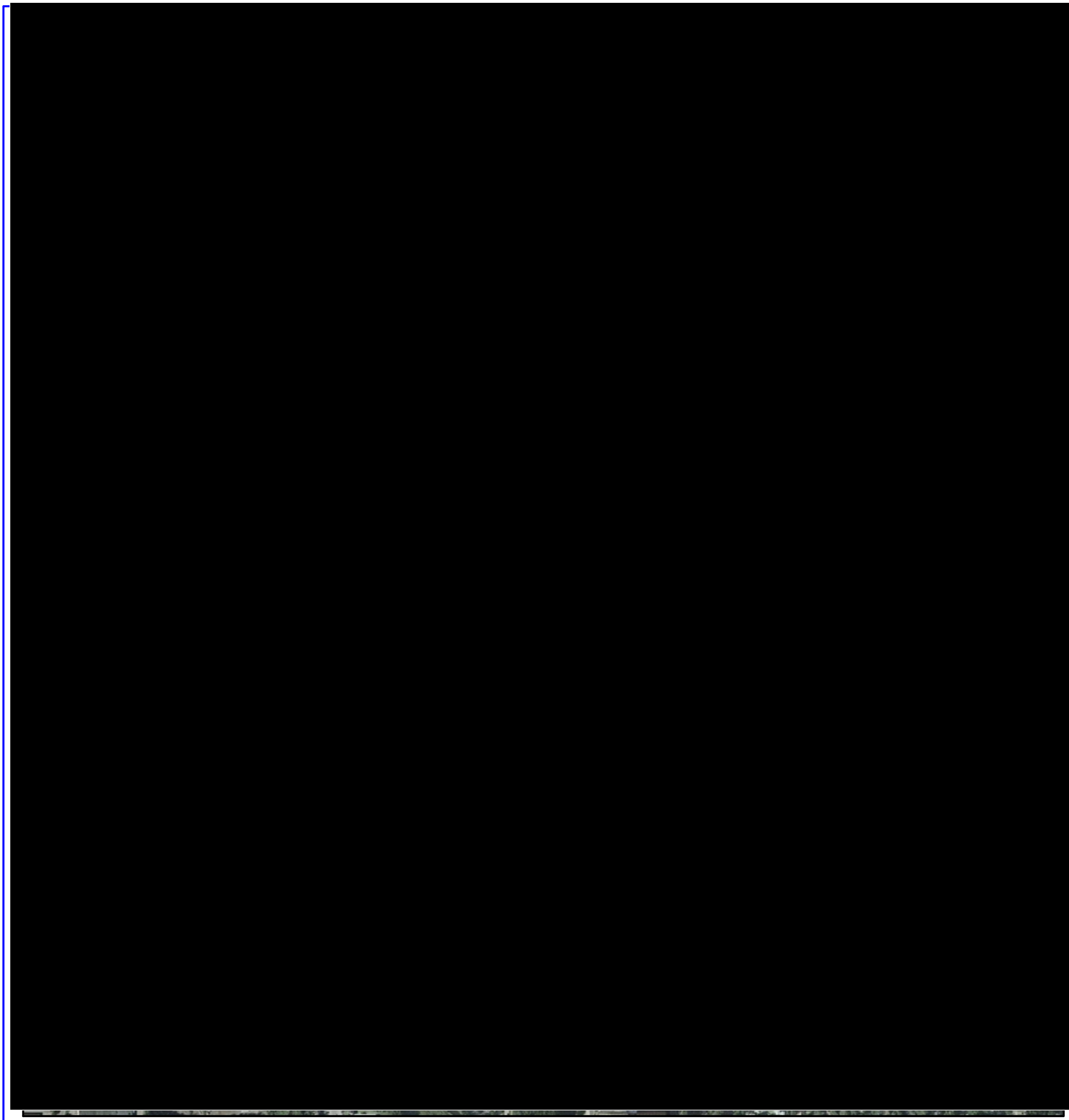
HISTORIC AND RECENT ISOCONCENTRATION MAPS FOR THE ST. PETER AQUIFER (1988,1996,2004,2012)

Reilly Site
St. Louis Park, Minnesota

Figure 12

File: 20121119_PAHSum31_OverTime
Summit Proj. No.: 0987-0009
Plot Date: 12-10-12
Arc Operator: PRB
Reviewed by: BMG

Summit Envirosolutions ®



Map adapted from NAIP Othophotograpy

Legend

- Drift/Platteville Well
- Capture Zone - W420
- Capture Zone - W439

Potentiometric Surface

Feet ASL

- 864 - 876
- 877 - 878
- 879 - 880
- 881 - 881
- 882 - 884

N

W E

S

0 1,000 2,000 Feet

POTENTIOMETRIC SURFACE AND CAPTURE ZONES - 6/2009

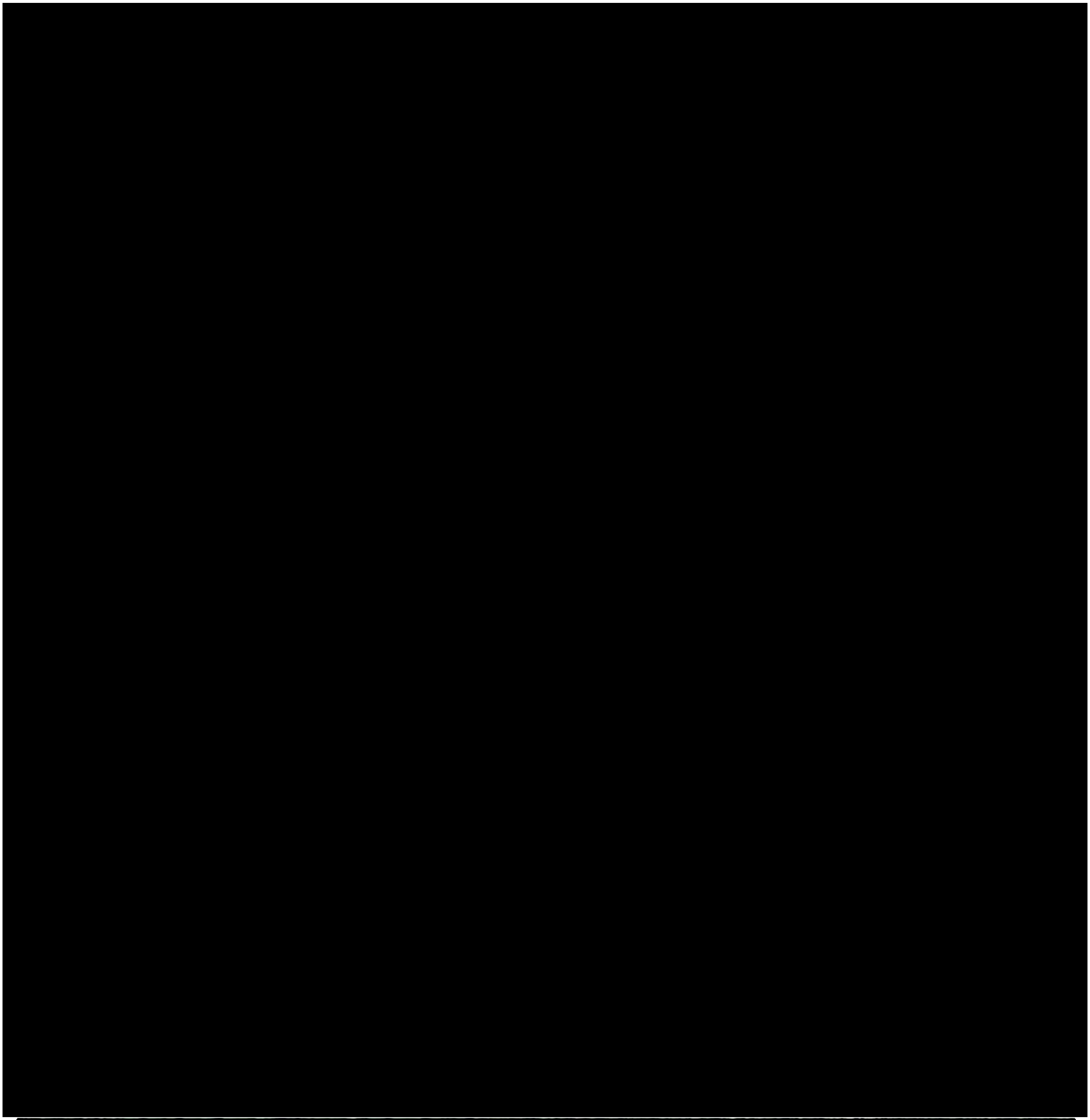
Drift/Platteville Wells

Reilly Site, City of St. Louis Park, Minnesota

Summit Envirosolutions ®

Figure 13

File: 20121030_capturezone.mxd
Summit Proj. No.: 0987-0009
Plot Date: 10-30-12
Arc Operator: JED
Reviewed by: PRB



Map adapted from NAIP Othophotograpy

Legend

St. Peter Well

Potentiometric Surface

Feet ASL

- 832 - 845
- 846 - 854
- 855 - 860
- 861 - 863
- 864 - 873

N W E S

0 1,000 2,000 Feet

POTENTIOMETRIC SURFACE AND CAPTURE ZONE - 6/2009
St. Peter Wells
Reilly Site, City of St. Louis Park, Minnesota

Summit Envirosolutions ®

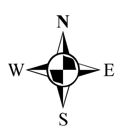
Figure 2

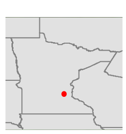
File: 20121030_capturezone.mxd
Summit Proj. No.: 0987-0009
Plot Date: 10-30-12
Arc Operator: JED
Reviewed by: PRB

Map adapted from ESRI Basemap: World Street Map.

Explanation

- Proposed Drift and Platteville Sentry Wells
- Drift
- Platteville
- St. Peter
- Site Outline





LOCATION OF PROPOSED SENTRY WELLS

Reilly Site
St. Louis Park, Minnesota

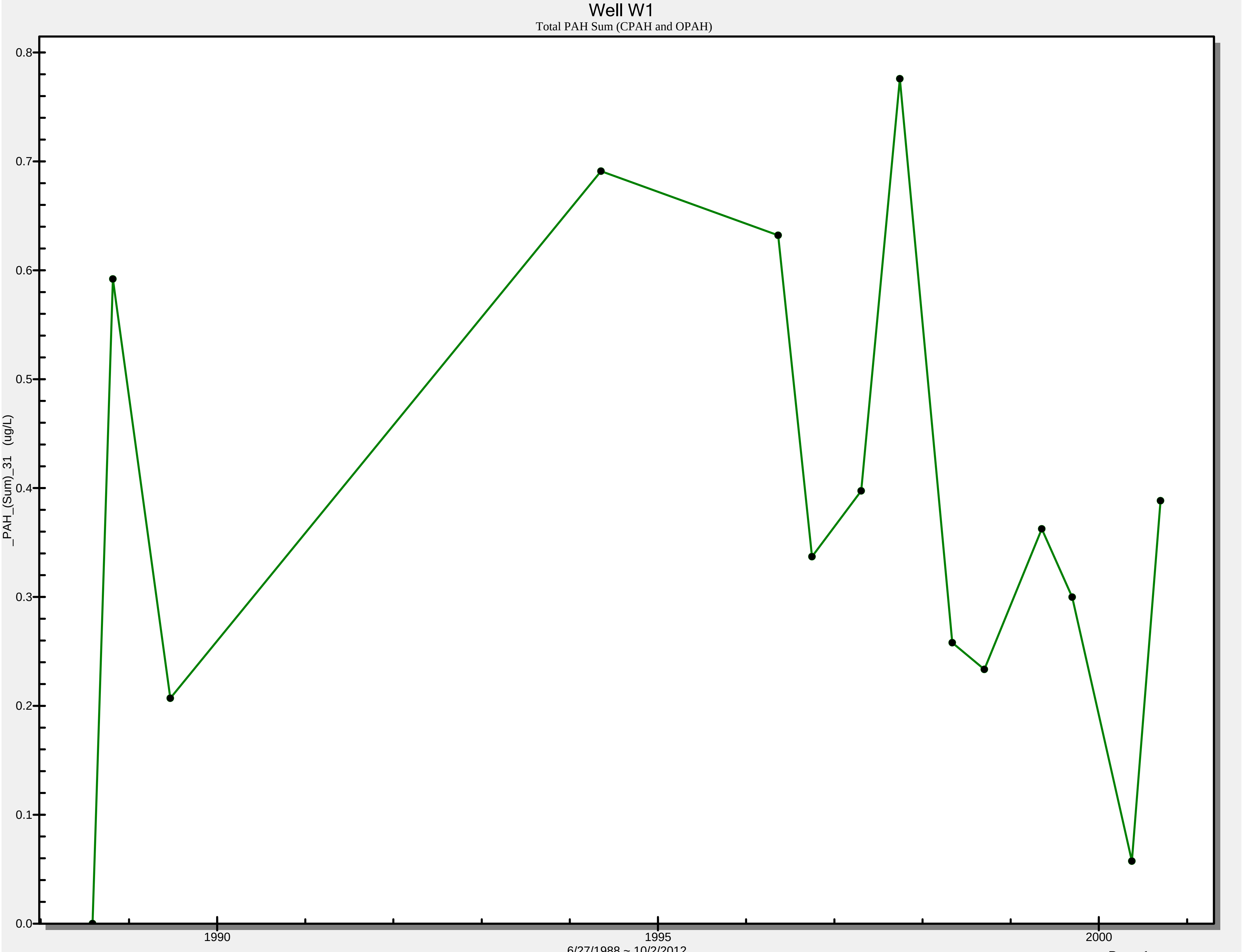
Summit Envirosolutions

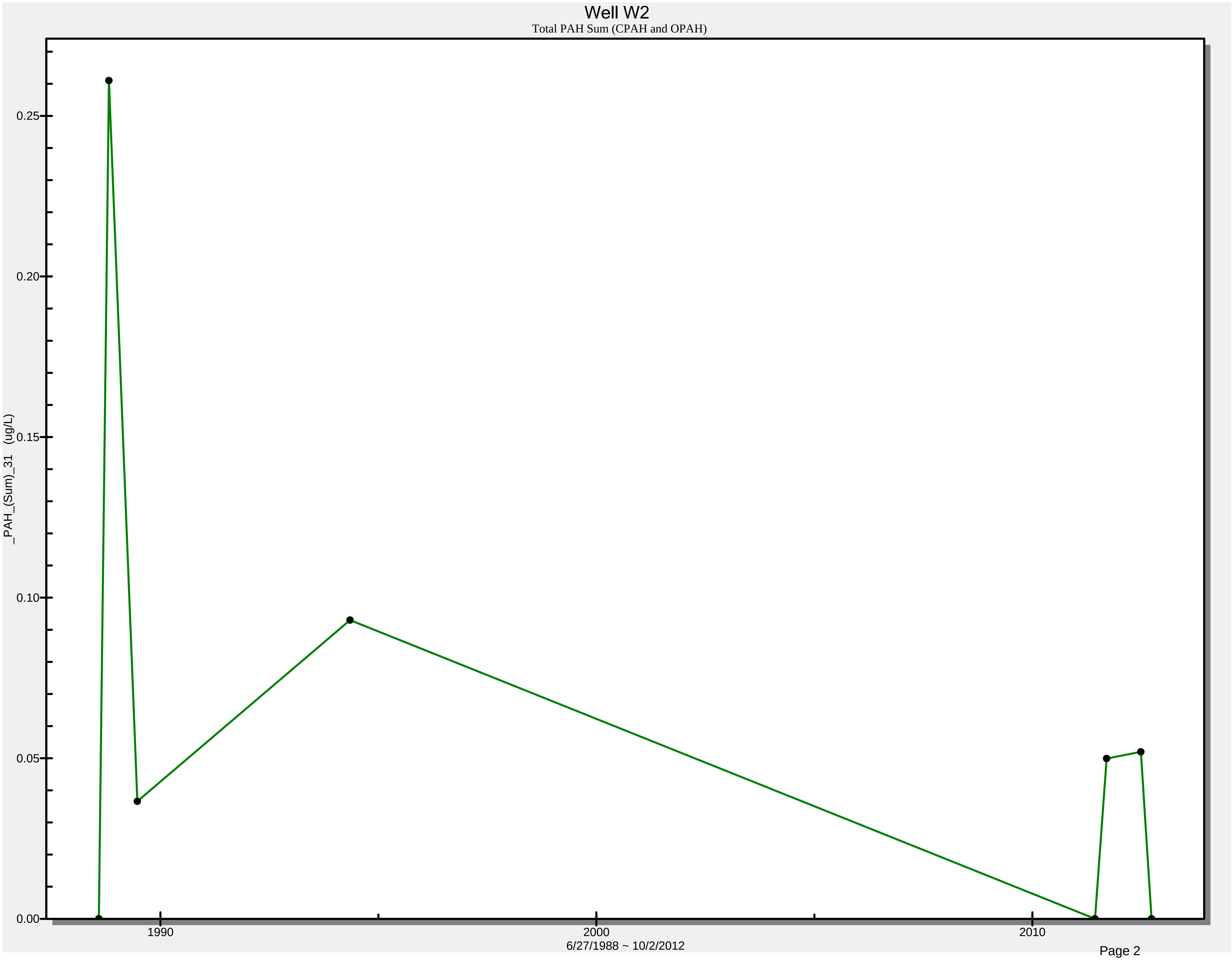
Figure 15

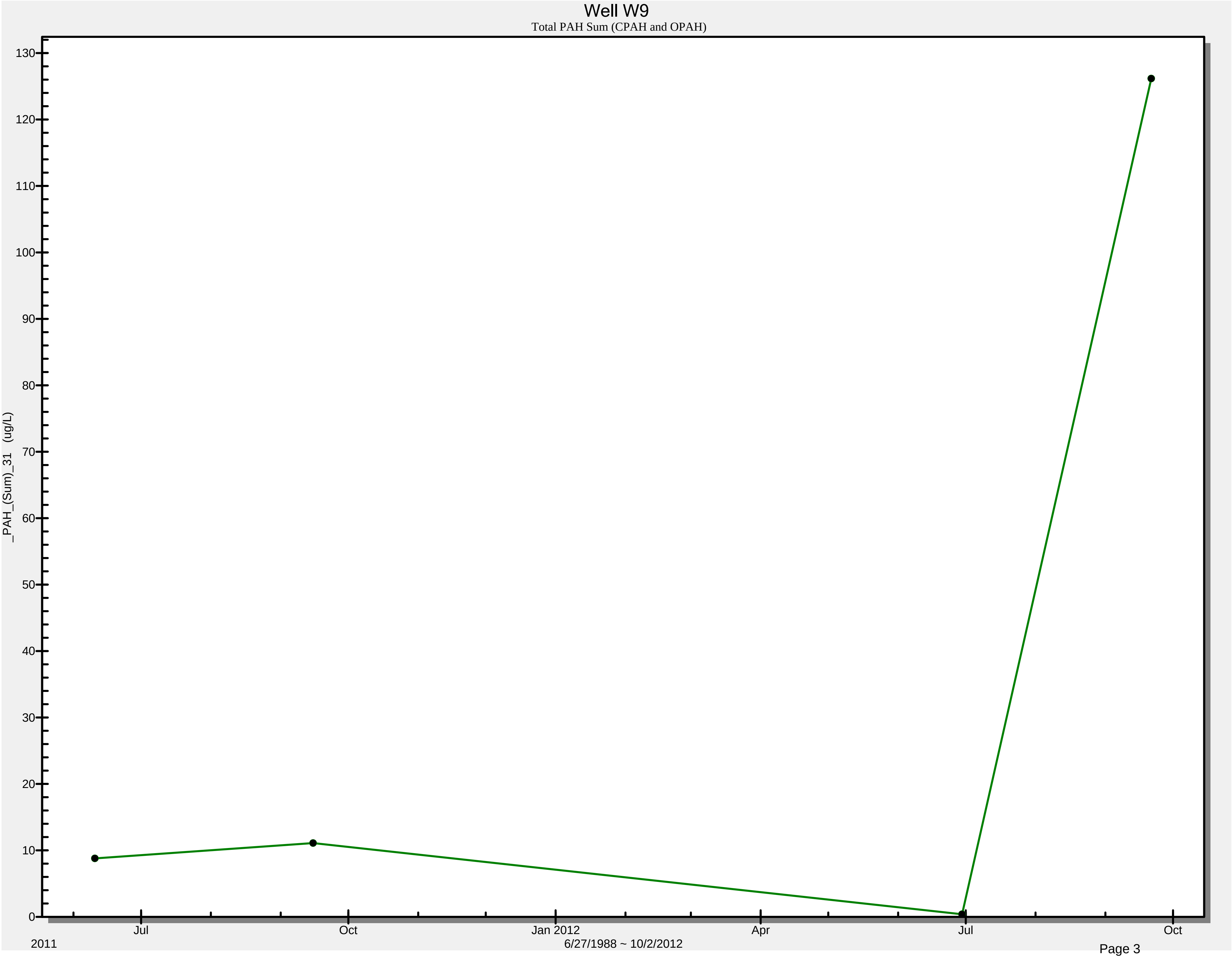
File:20121029_SampleLocs_Working
Summit Proj. No.: 0987-0009
Plot Date: 10-29-12
Arc Operator: PRB
Reviewed by: BMG

Appendix A

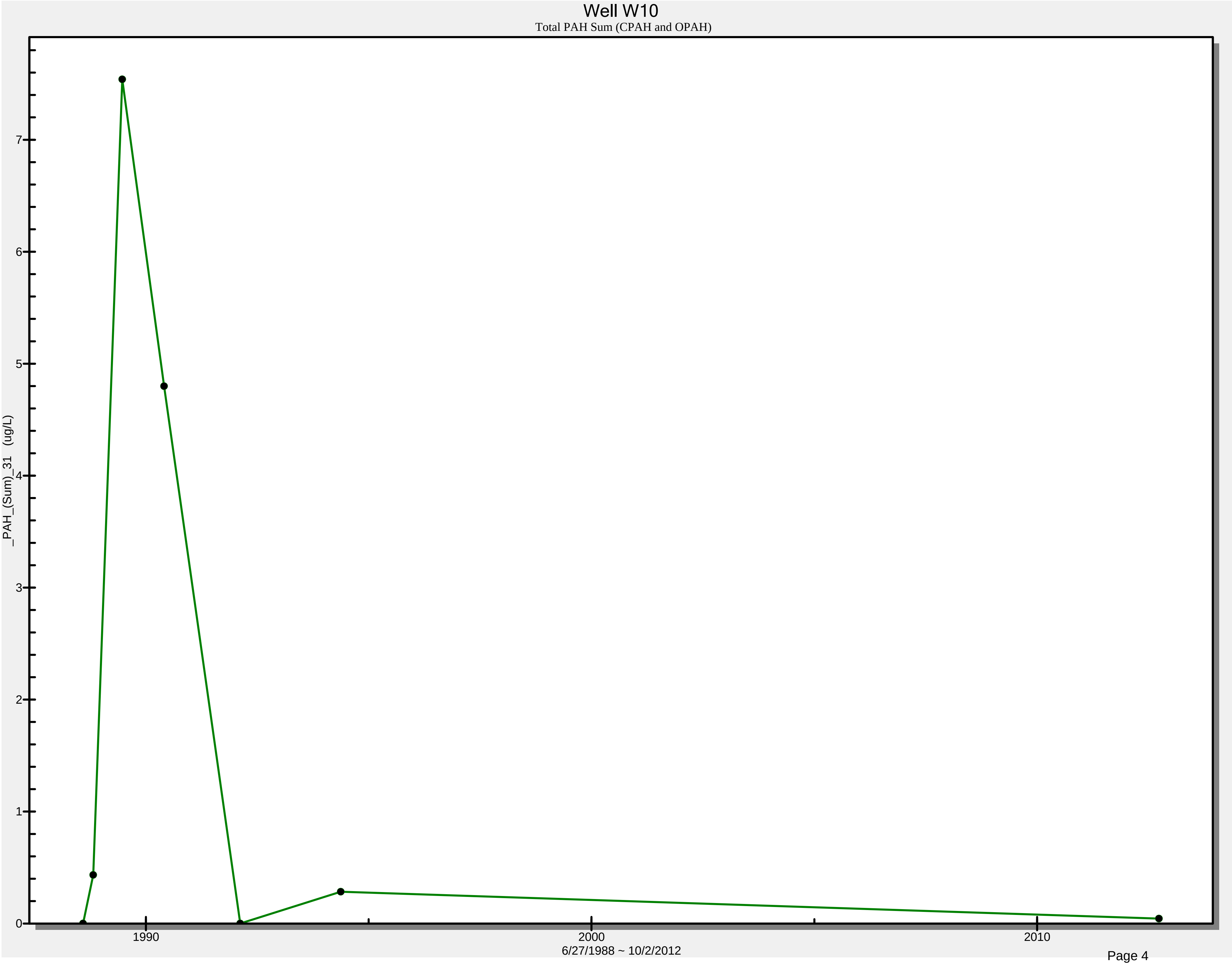
Graphs of Total PAH Over Time


Well W1
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
1995
2000
6/27/1988 ~ 10/2/2012

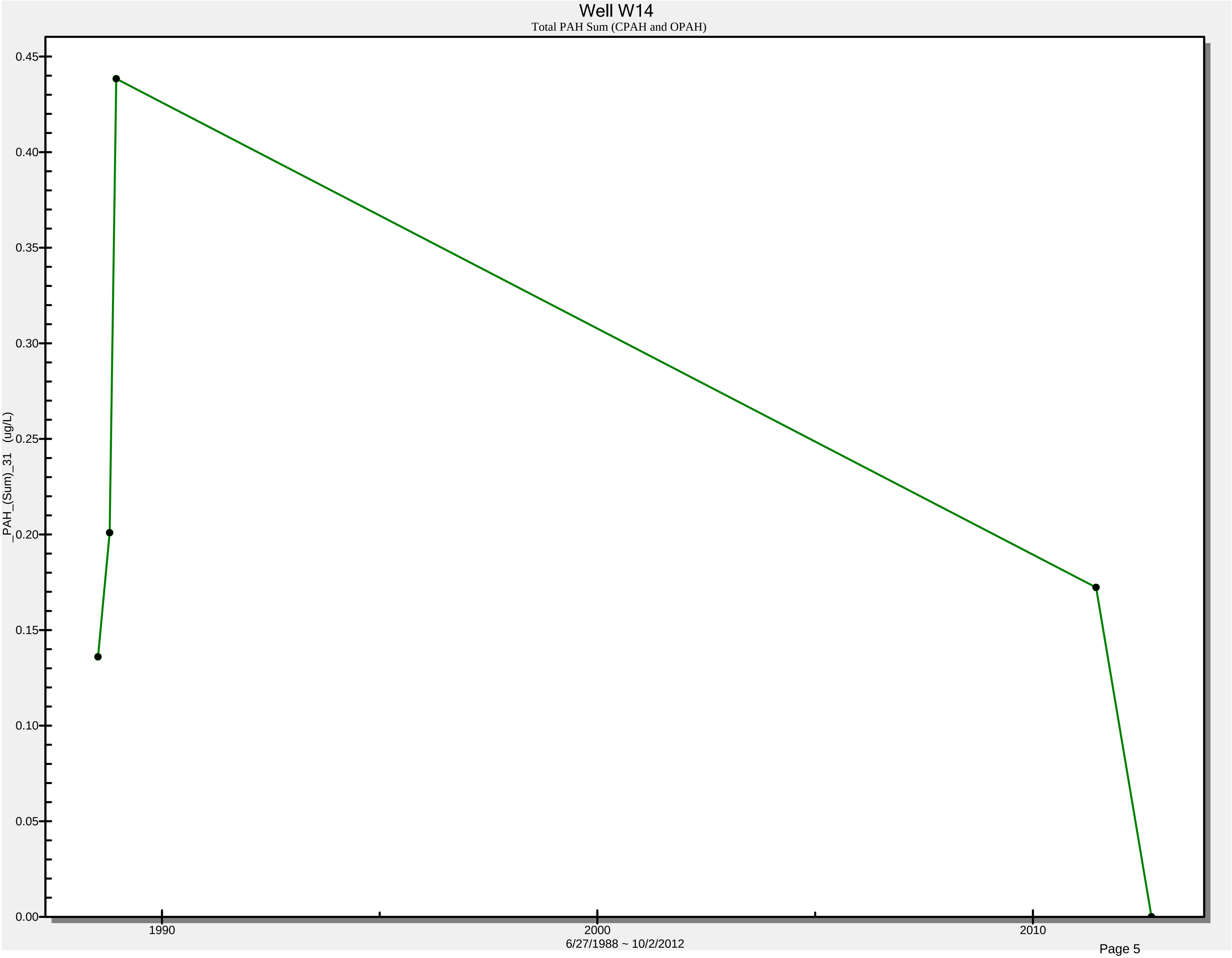

Well W2
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012

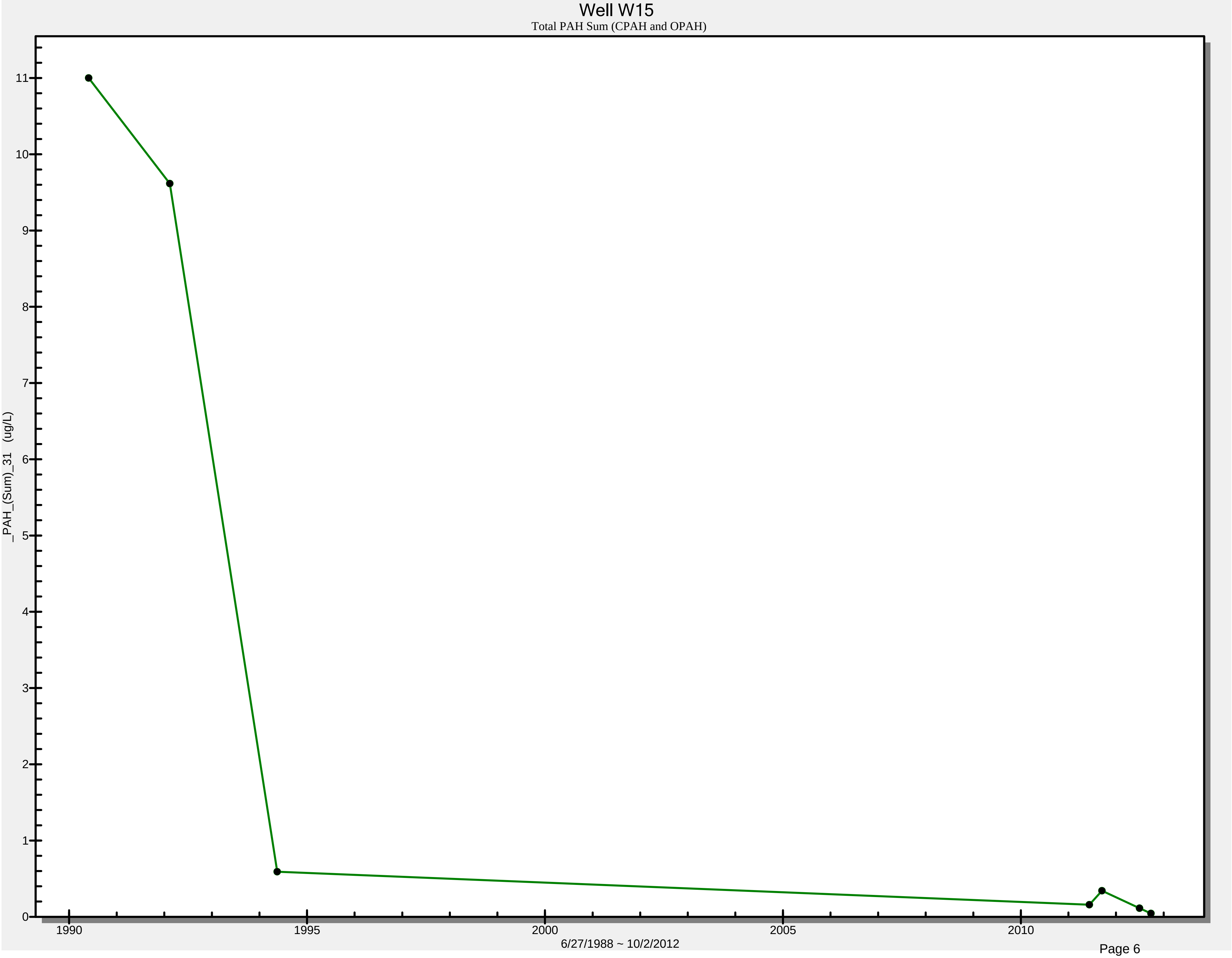


Well W9
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Jul
Oct
Jan 2012
Apr
Jul
Oct
2011
6/27/1988 ~ 10/2/2012

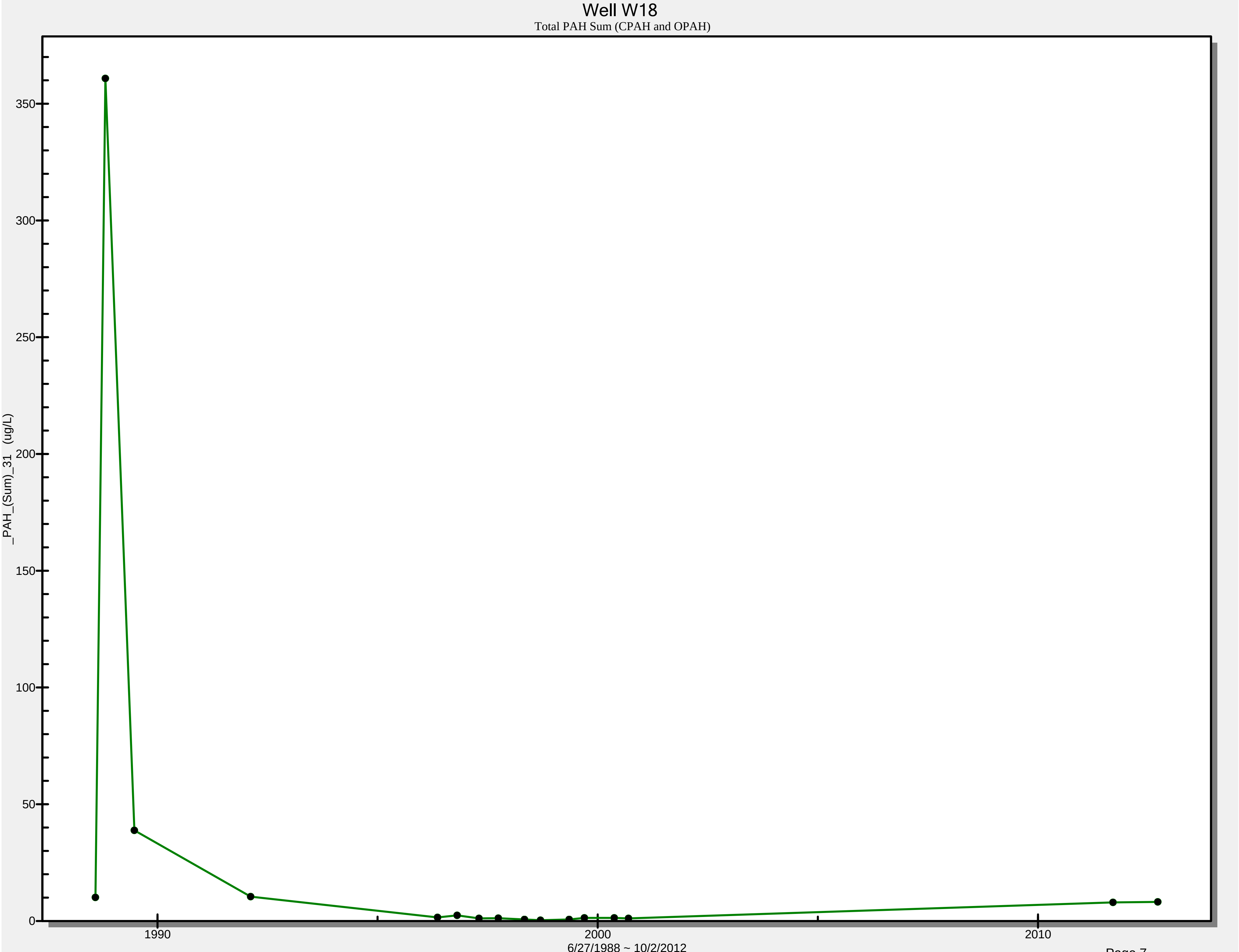


Well W10
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
1990
2000
2010
6/27/1988 ~ 10/2/2012

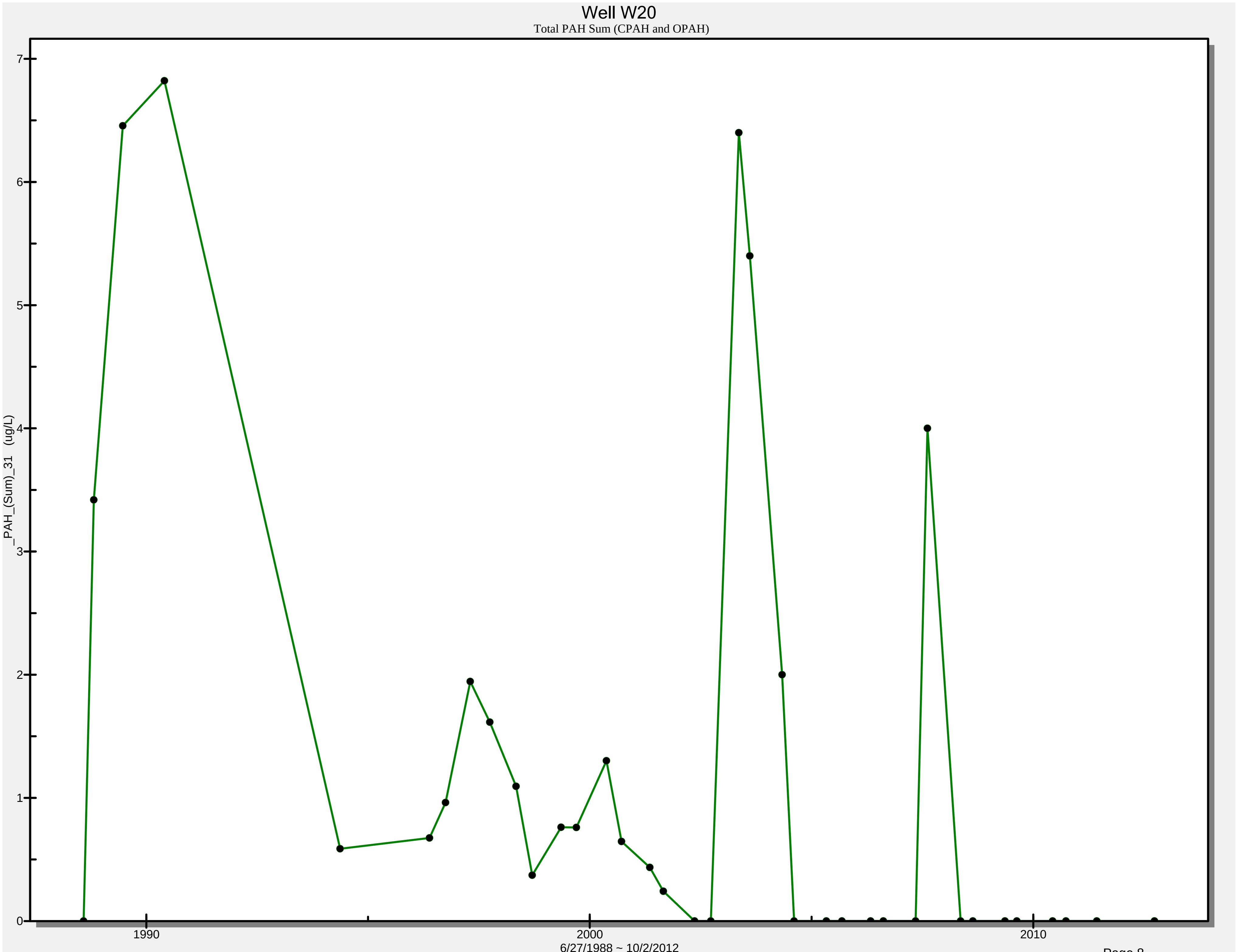

Well W14
Total PAH Sum (CPAH and OPAH)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
PAH(Sum)_31 (ug/L)
1990
2000
2010
6/27/1988 ~ 10/2/2012



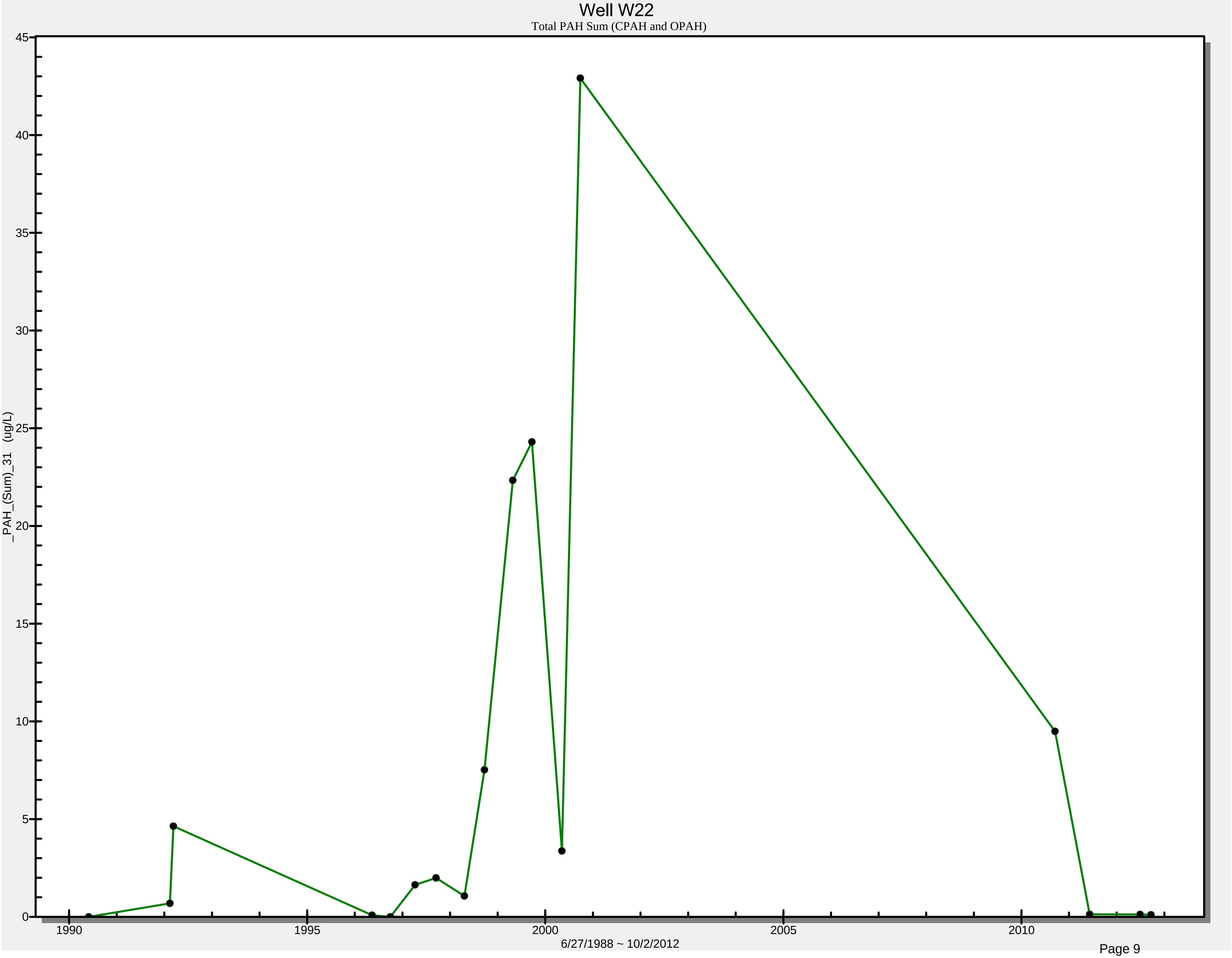
Well W15
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
9
10
11
1990
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012



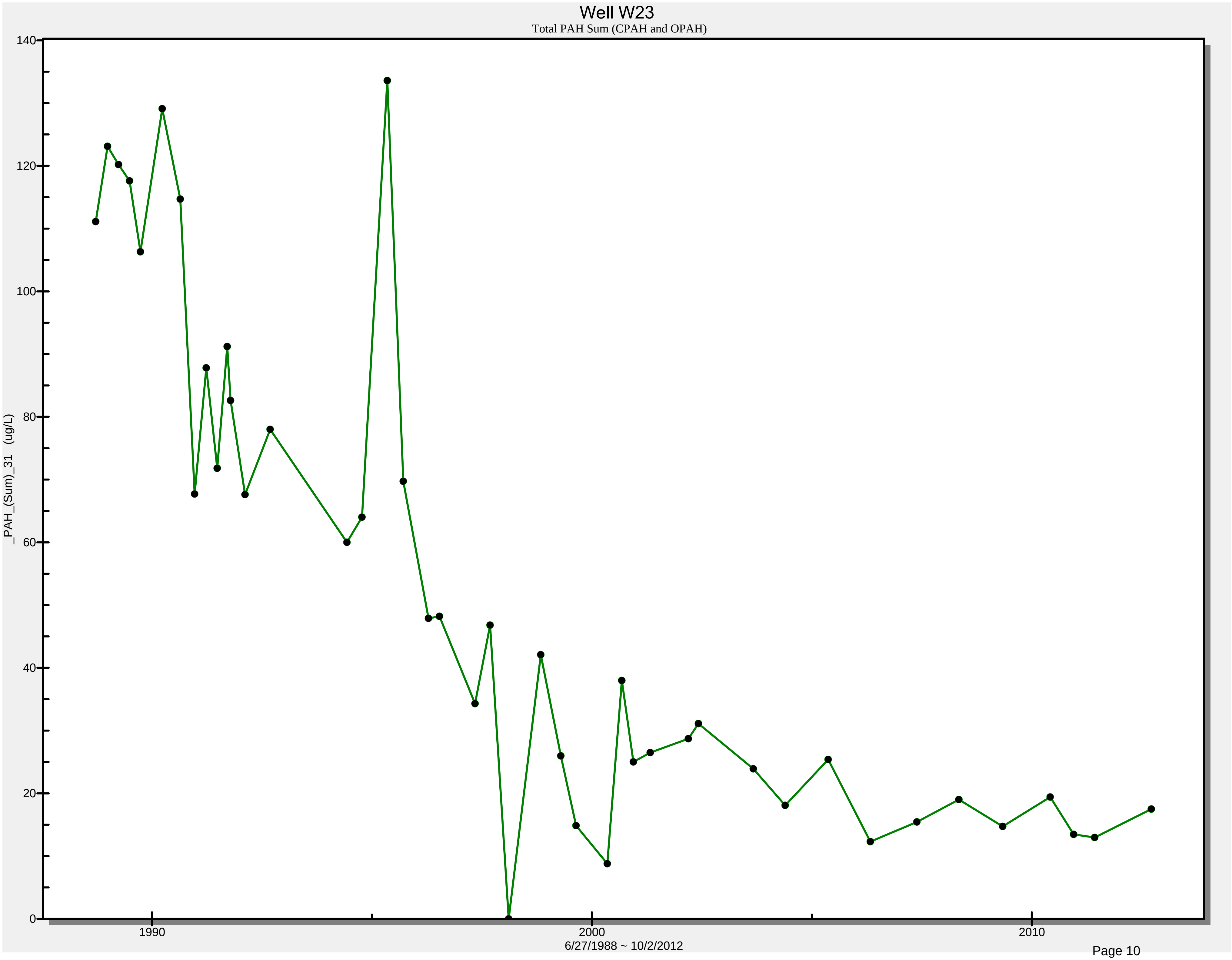
Well W18
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
50
100
150
200
250
300
350
1990
2000
2010
6/27/1988 ~ 10/2/2012



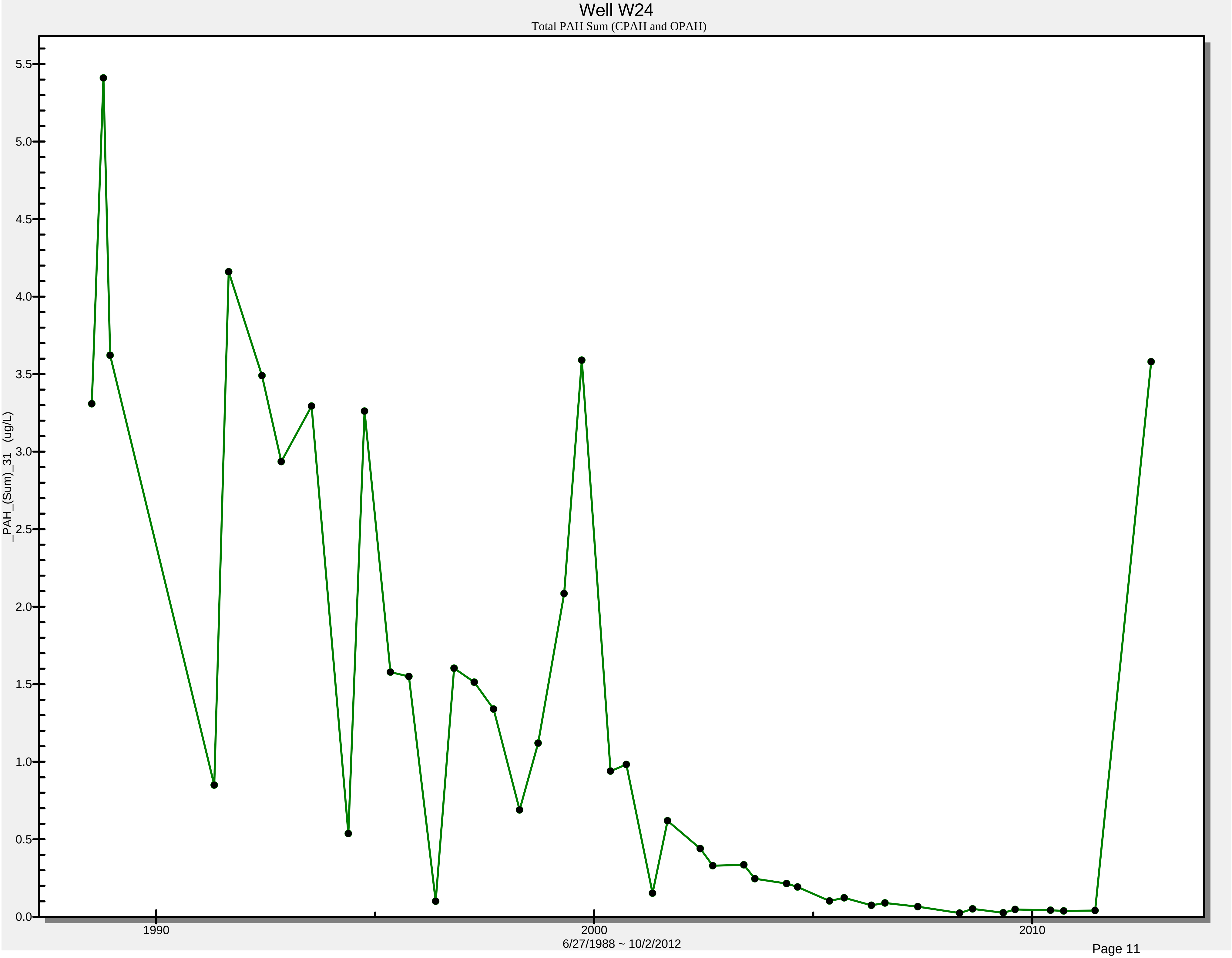
Well W20
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
1990
2000
2010
6/27/1988 ~ 10/2/2012



Well W22
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
5
10
15
20
25
30
35
40
45
1990
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

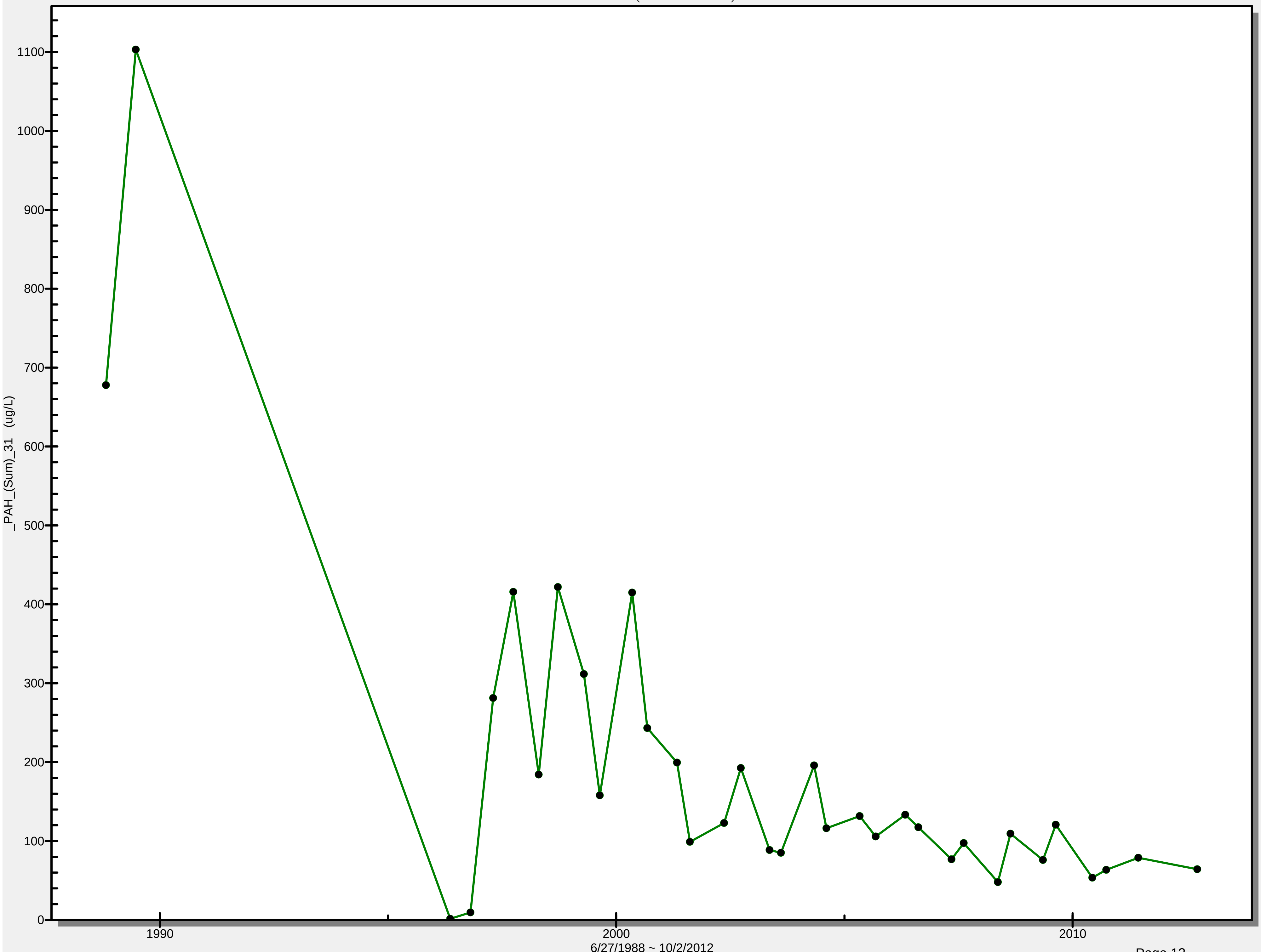


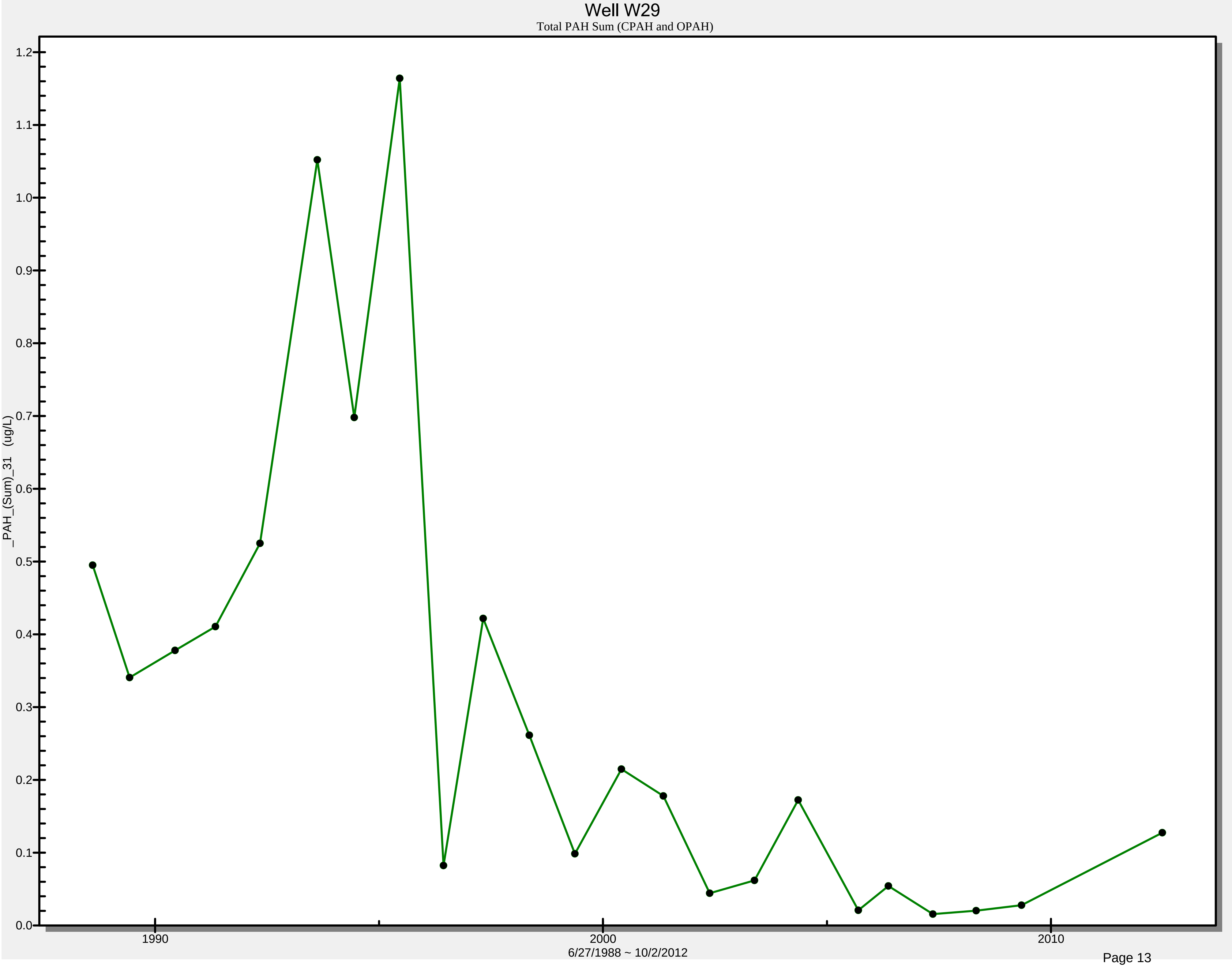
Well W23
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
20
40
60
80
100
120
140
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well W24
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
1990
2000
2010
6/27/1988 ~ 10/2/2012

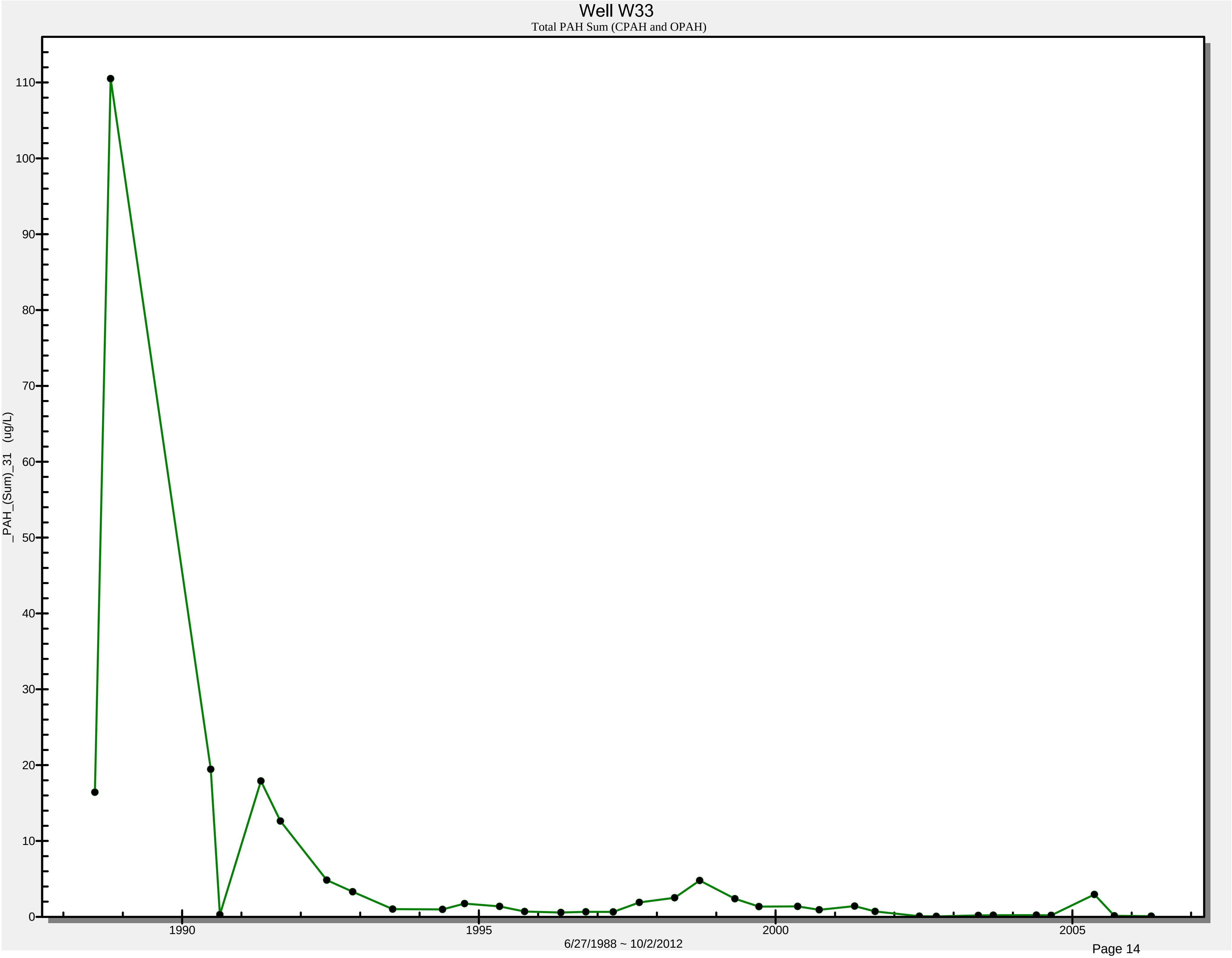
Well W27

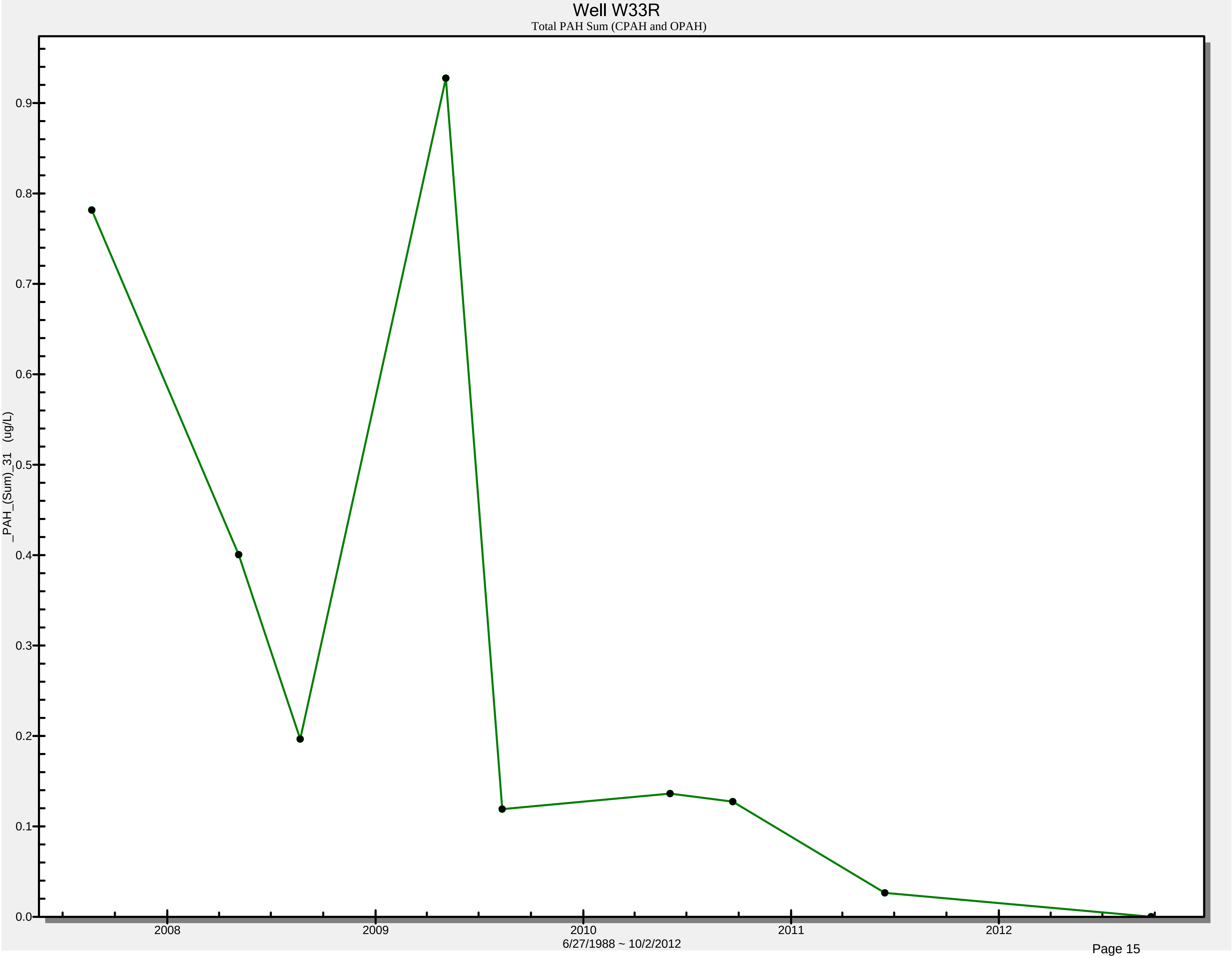
Total PAH Sum (CPAH and OPAH)



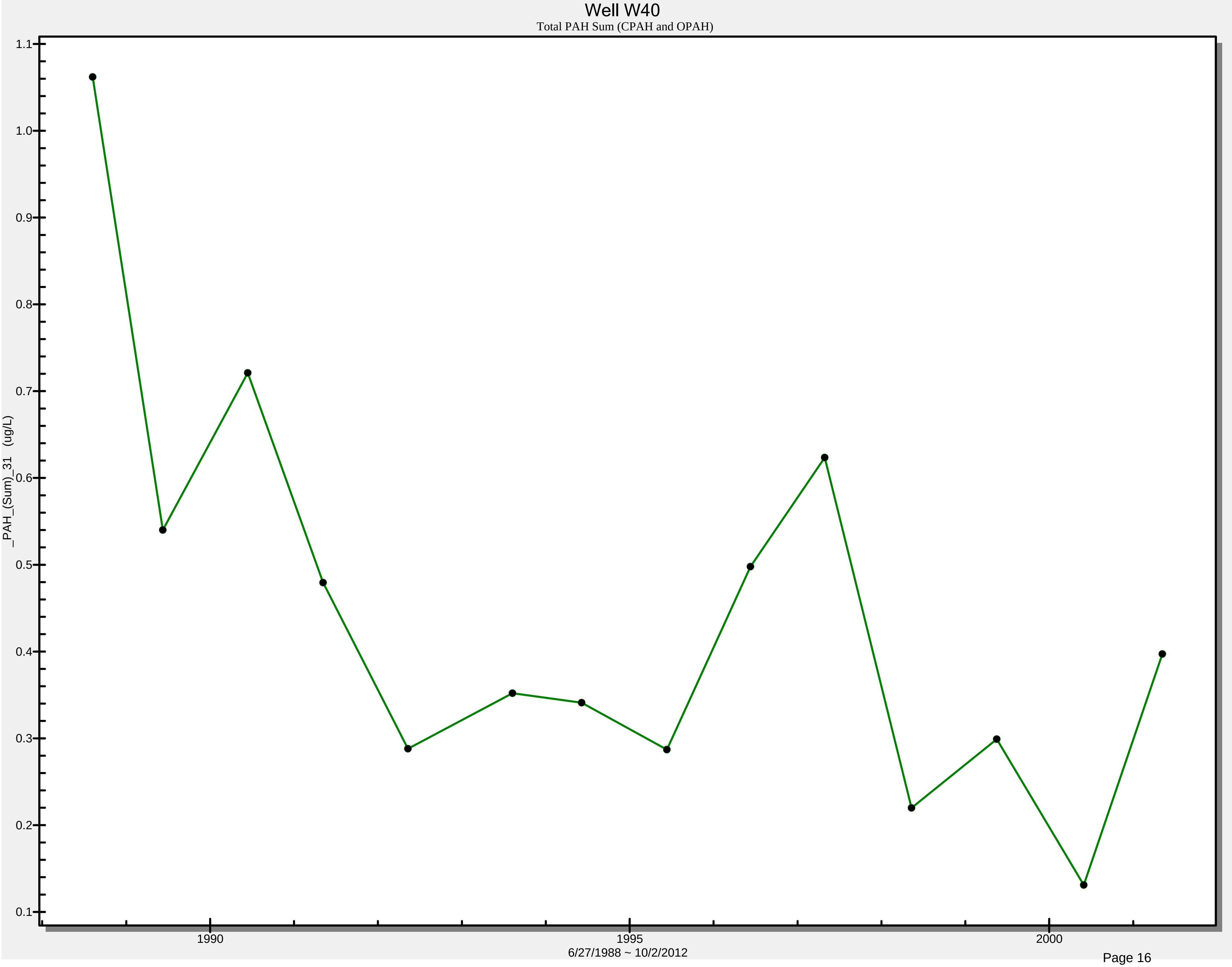


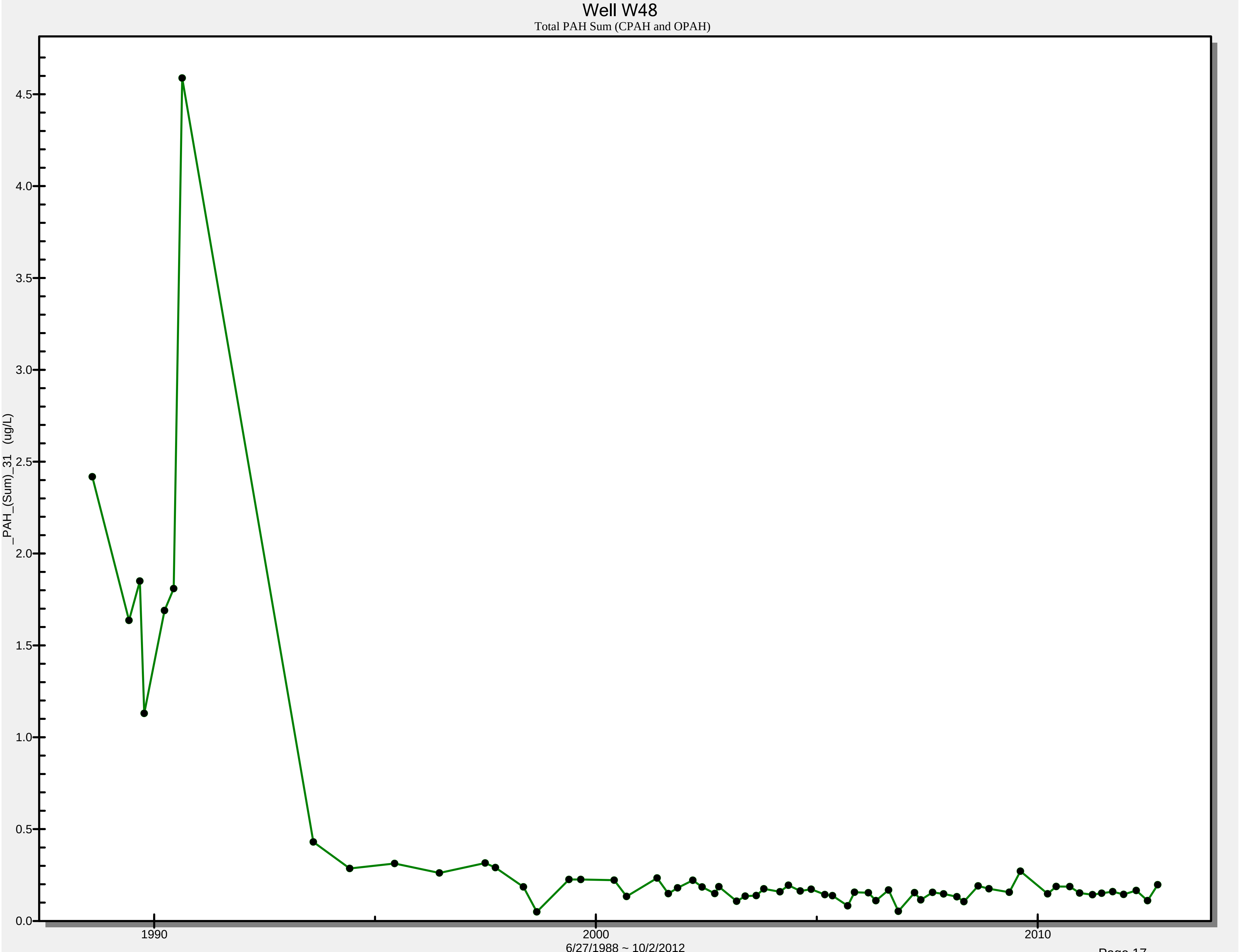
Well W29
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012

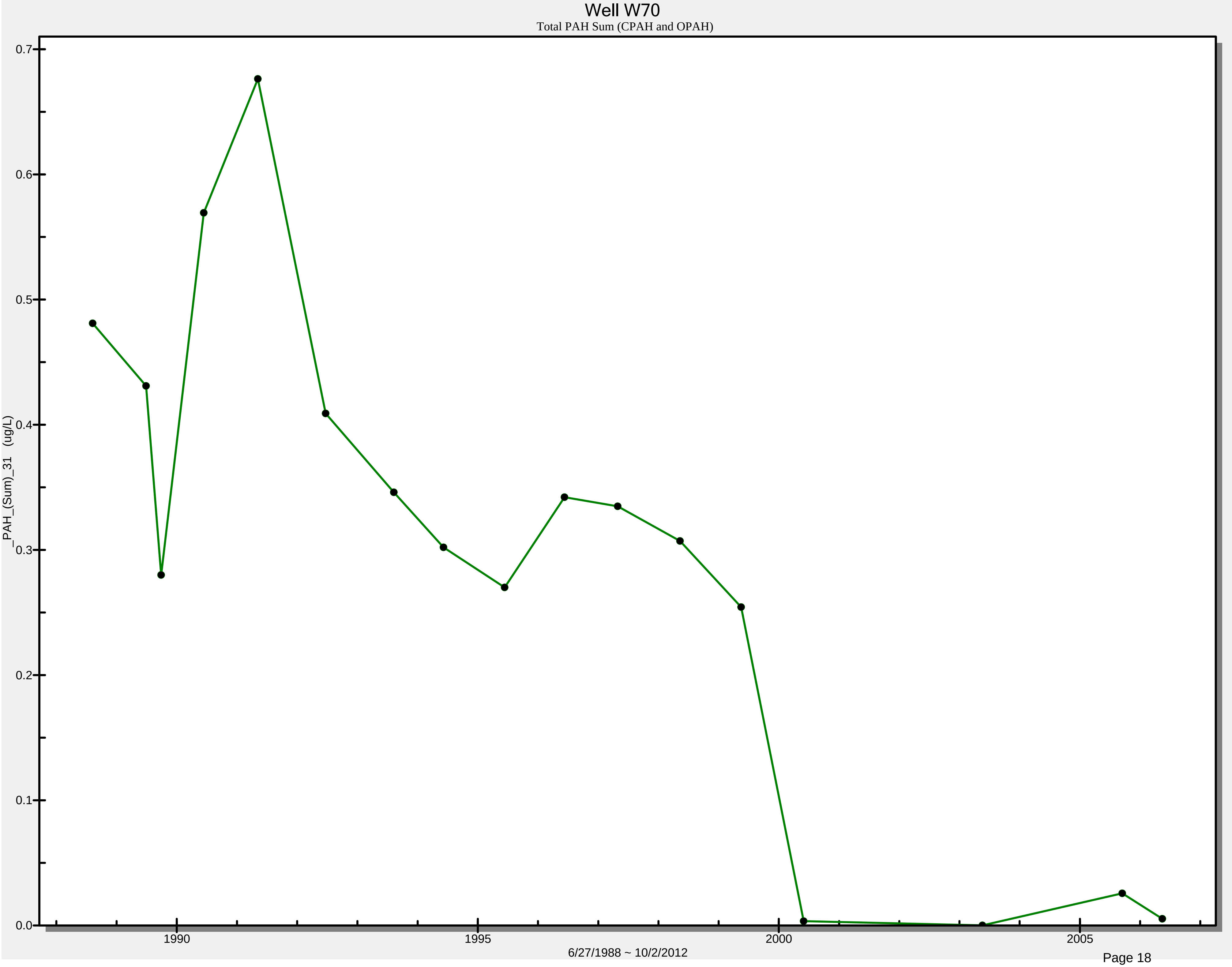

Well W33
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
10
20
30
40
50
60
70
80
90
100
110
1990
1995
2000
2005
6/27/1988 ~ 10/2/2012



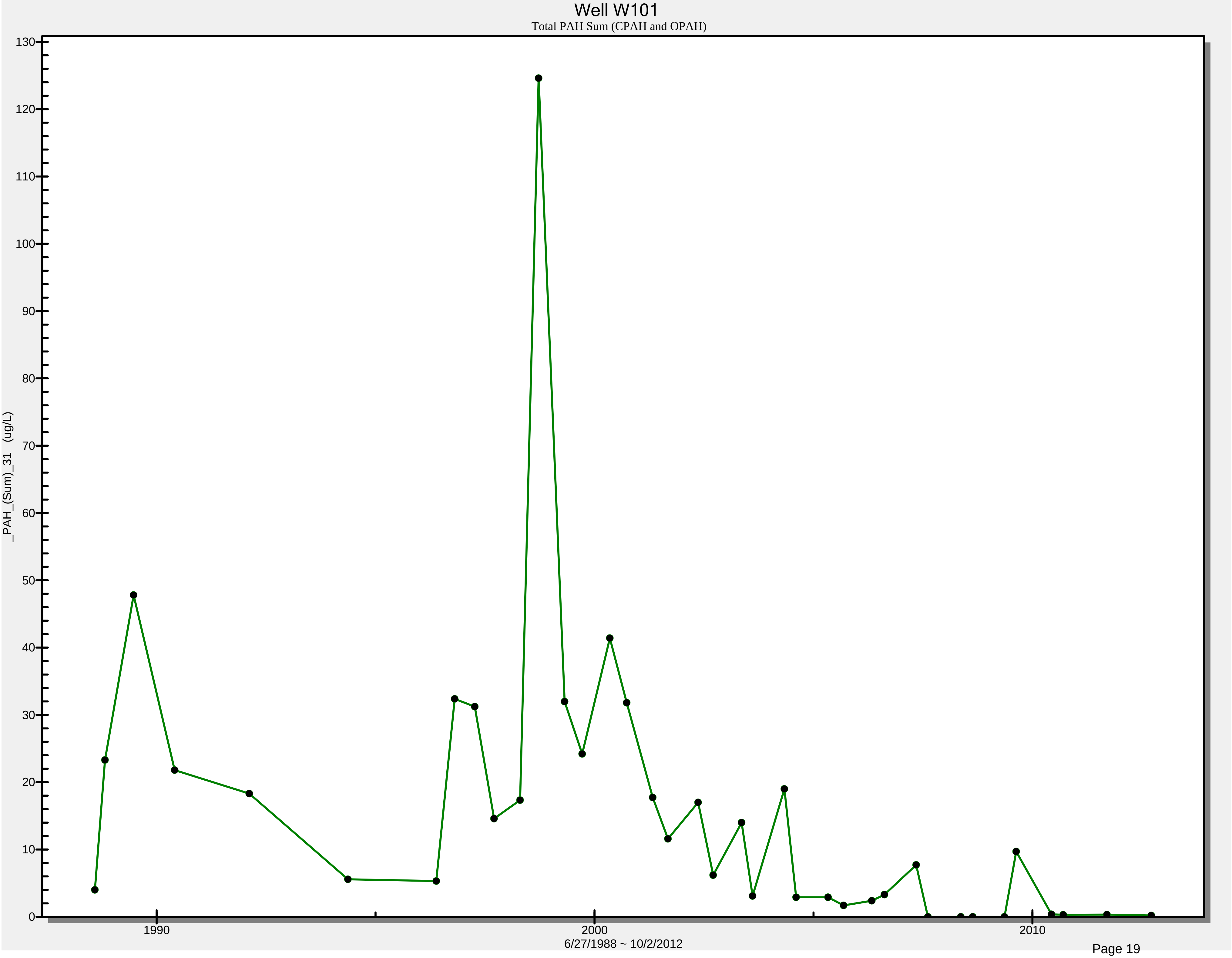
Well W33R
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
2008
2009
2010
2011
2012
6/27/1988 ~ 10/2/2012

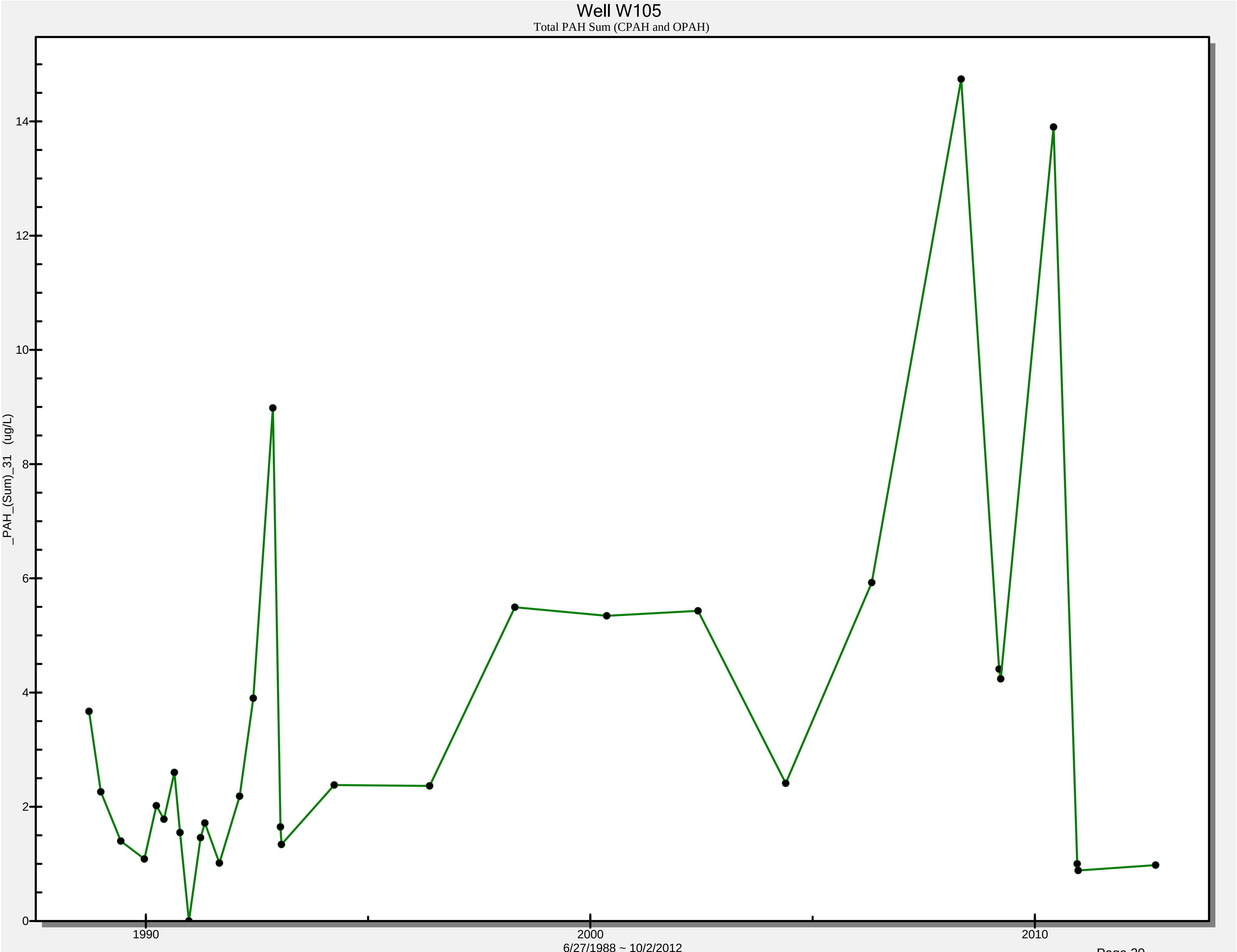

Well W40
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1990
1995
2000
6/27/1988 ~ 10/2/2012


Well W48
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
1990
2000
2010
6/27/1988 ~ 10/2/2012

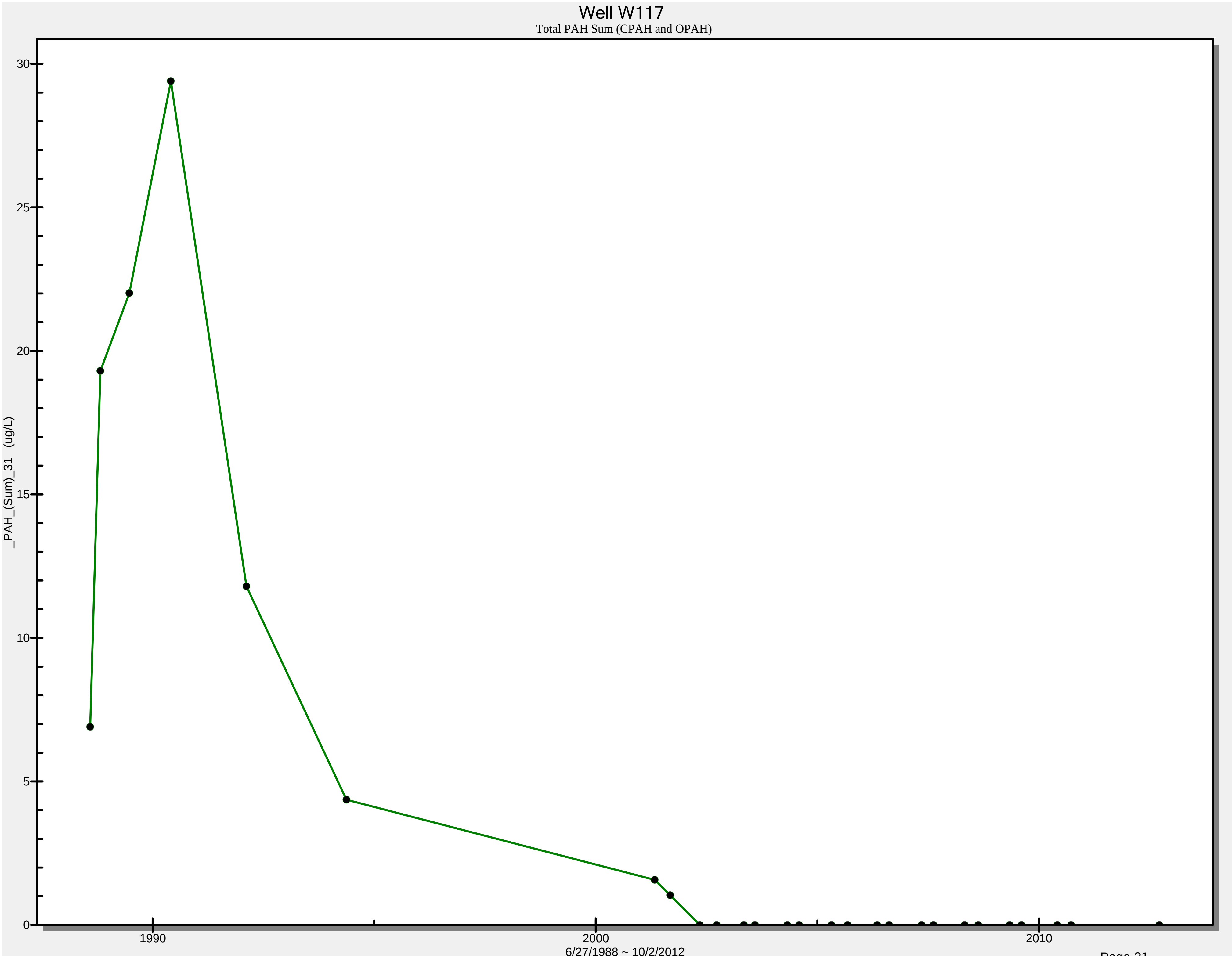


Well W70
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1990
1995
2000
2005
6/27/1988 ~ 10/2/2012

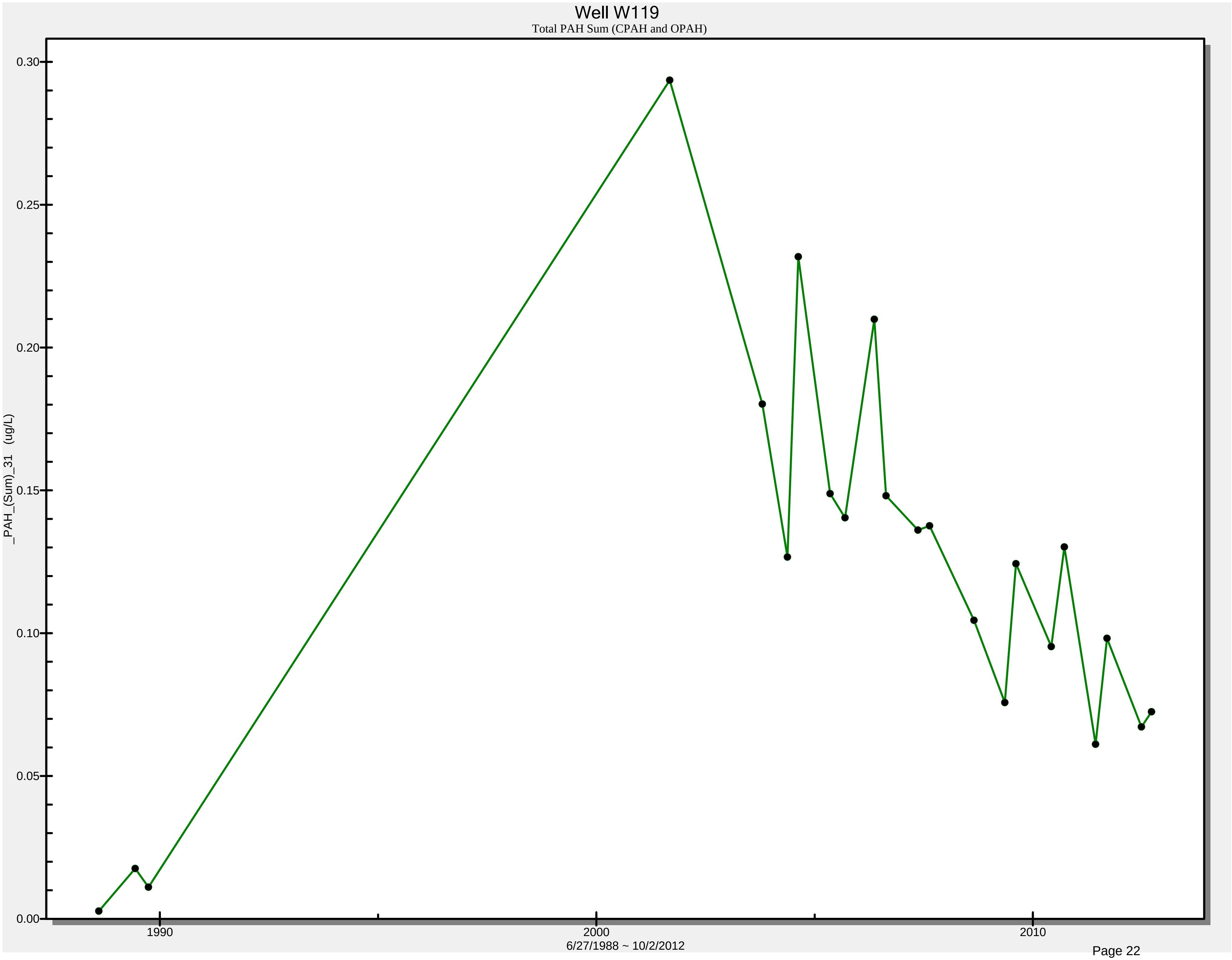

Well W101
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1990
2000
2010
6/27/1988 ~ 10/2/2012

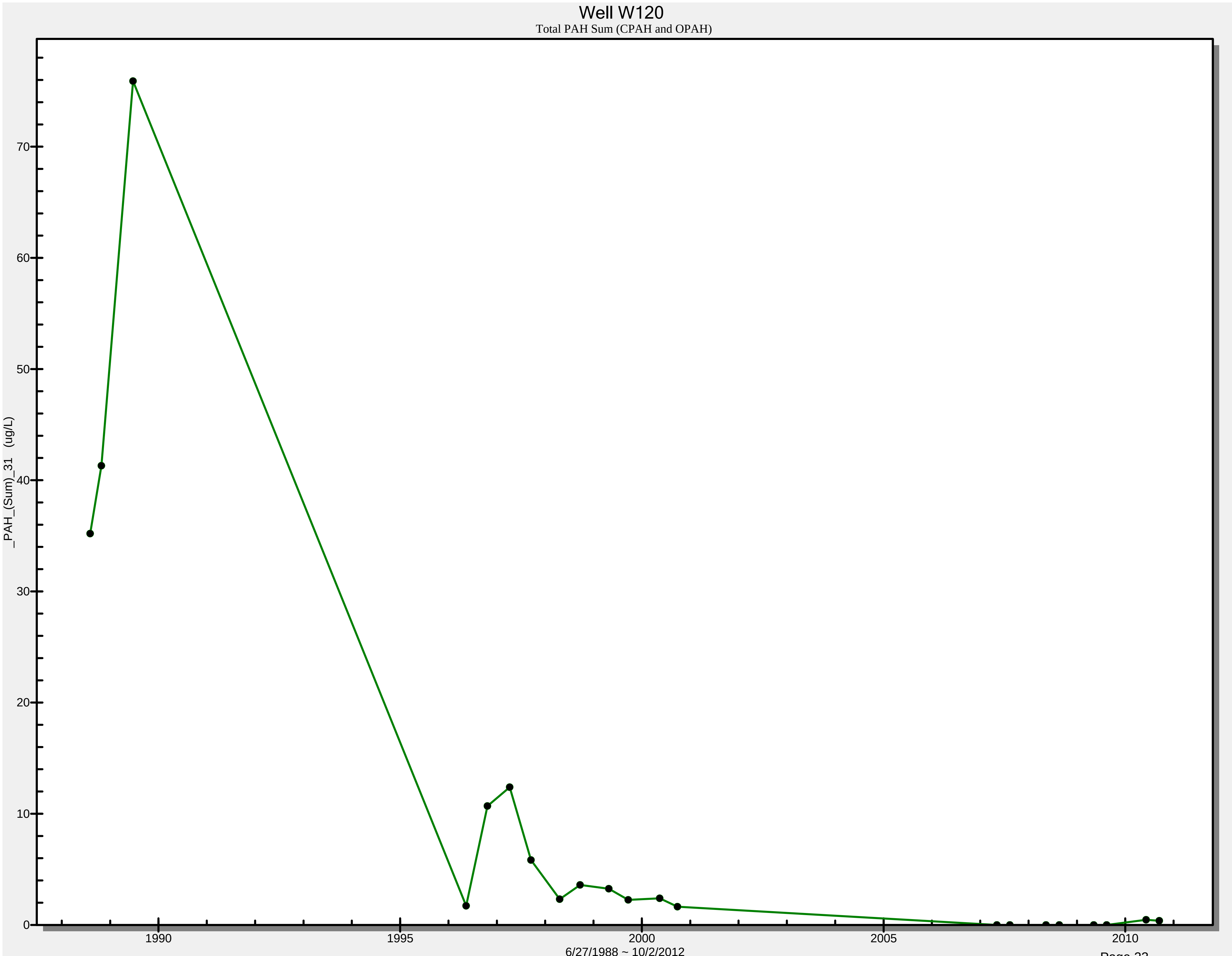


Well W105
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
2
4
6
8
10
12
14
1990
2000
2010
6/27/1988 ~ 10/2/2012

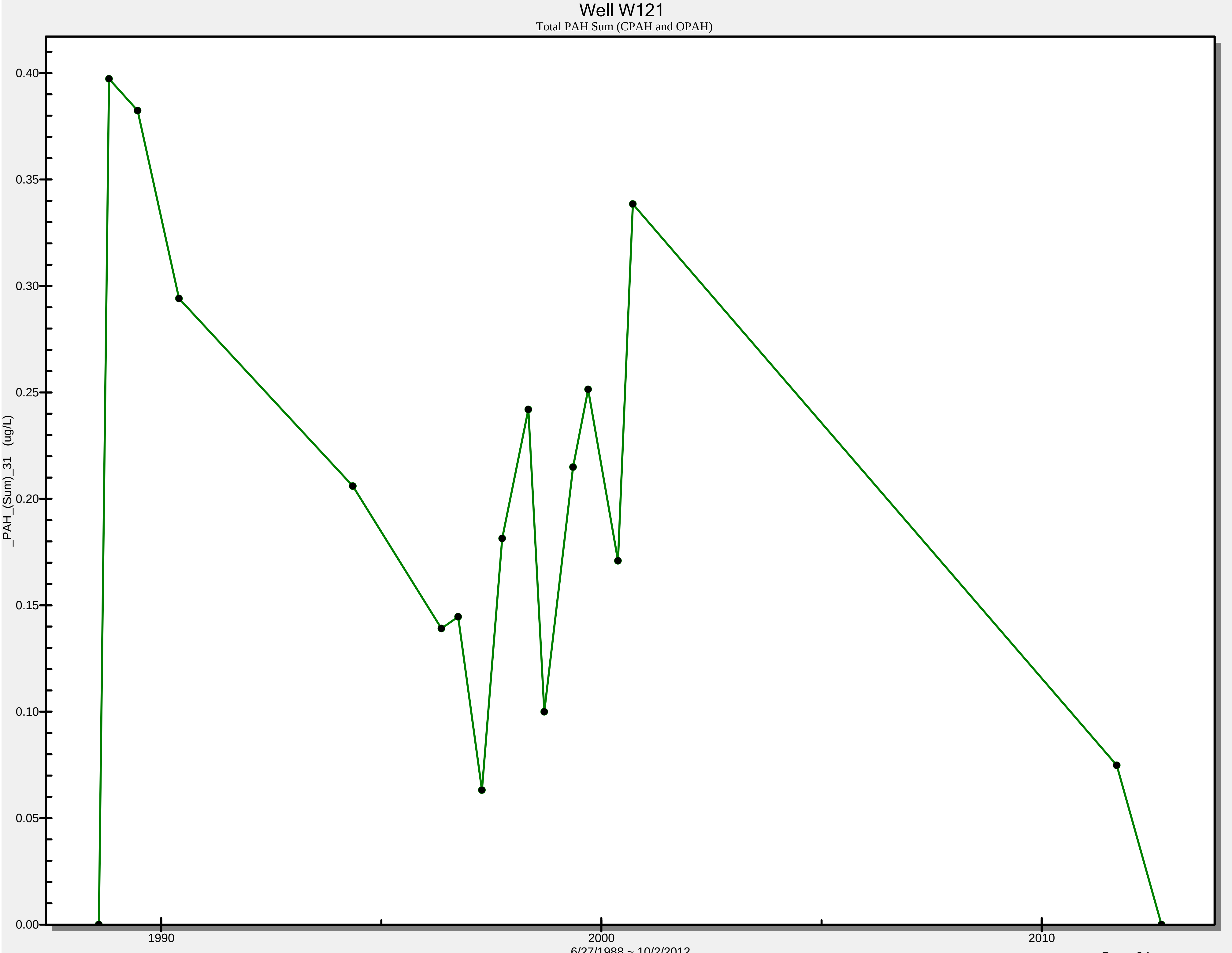


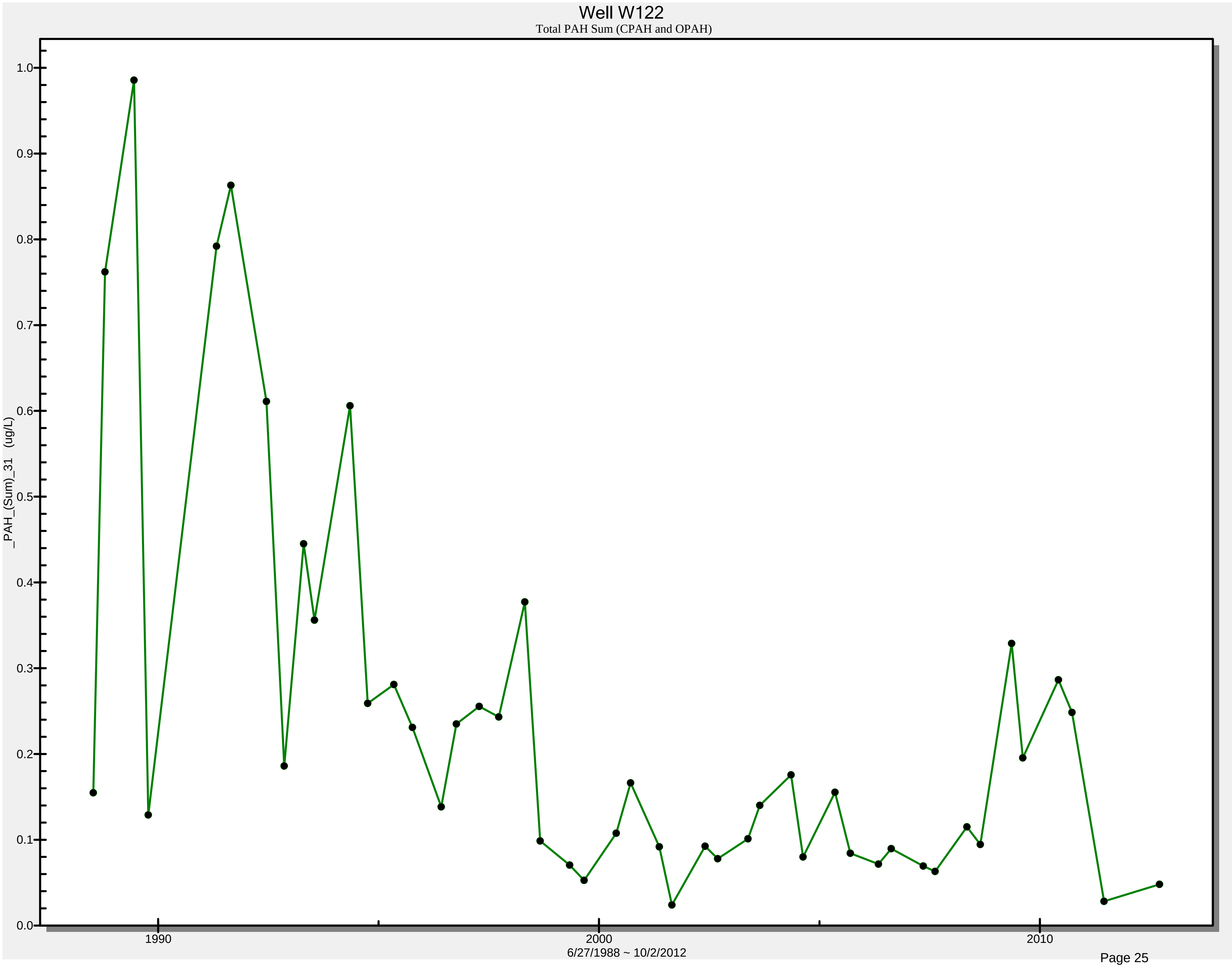
Well W117
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
30
25
20
15
10
5
0
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well W119
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012

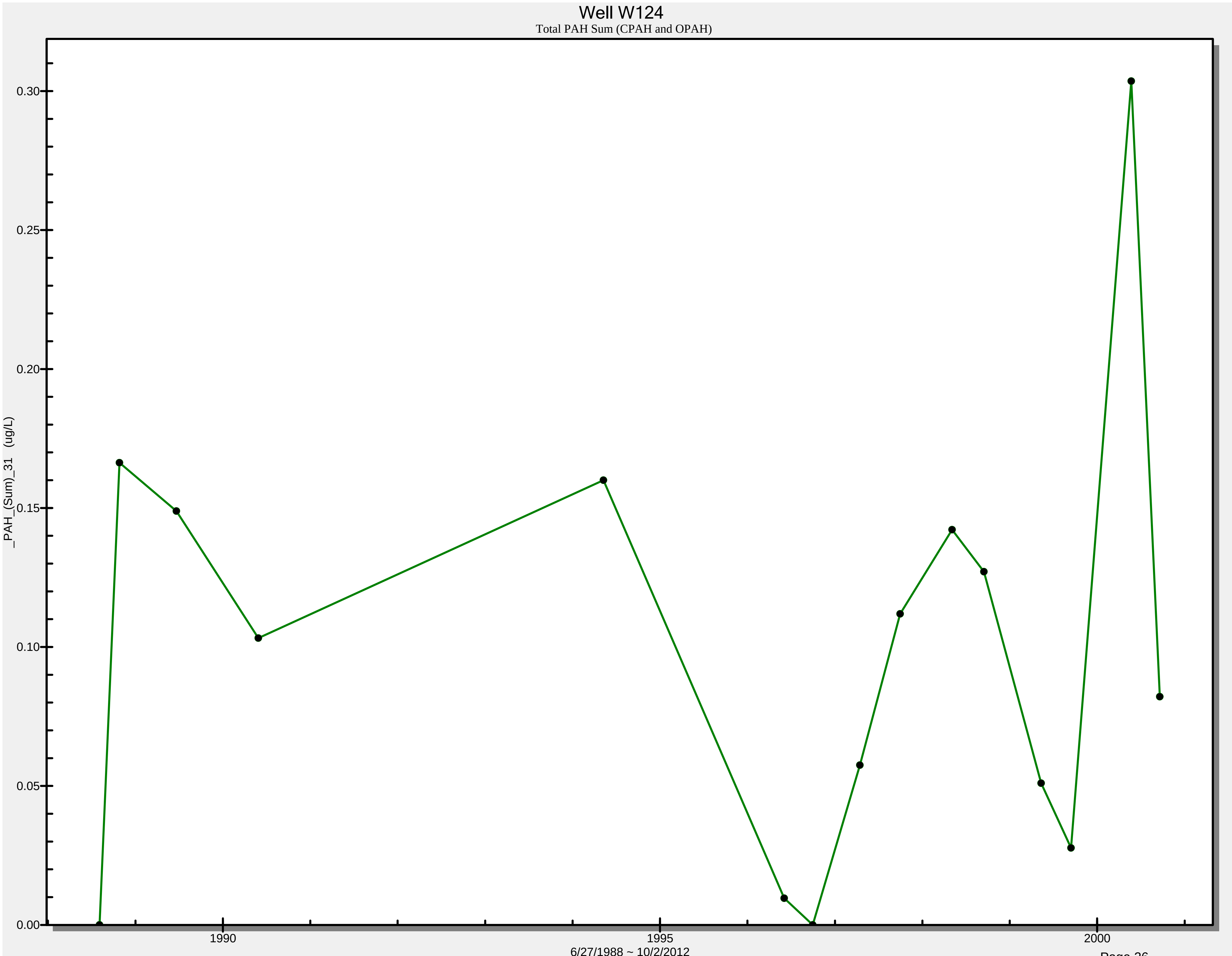


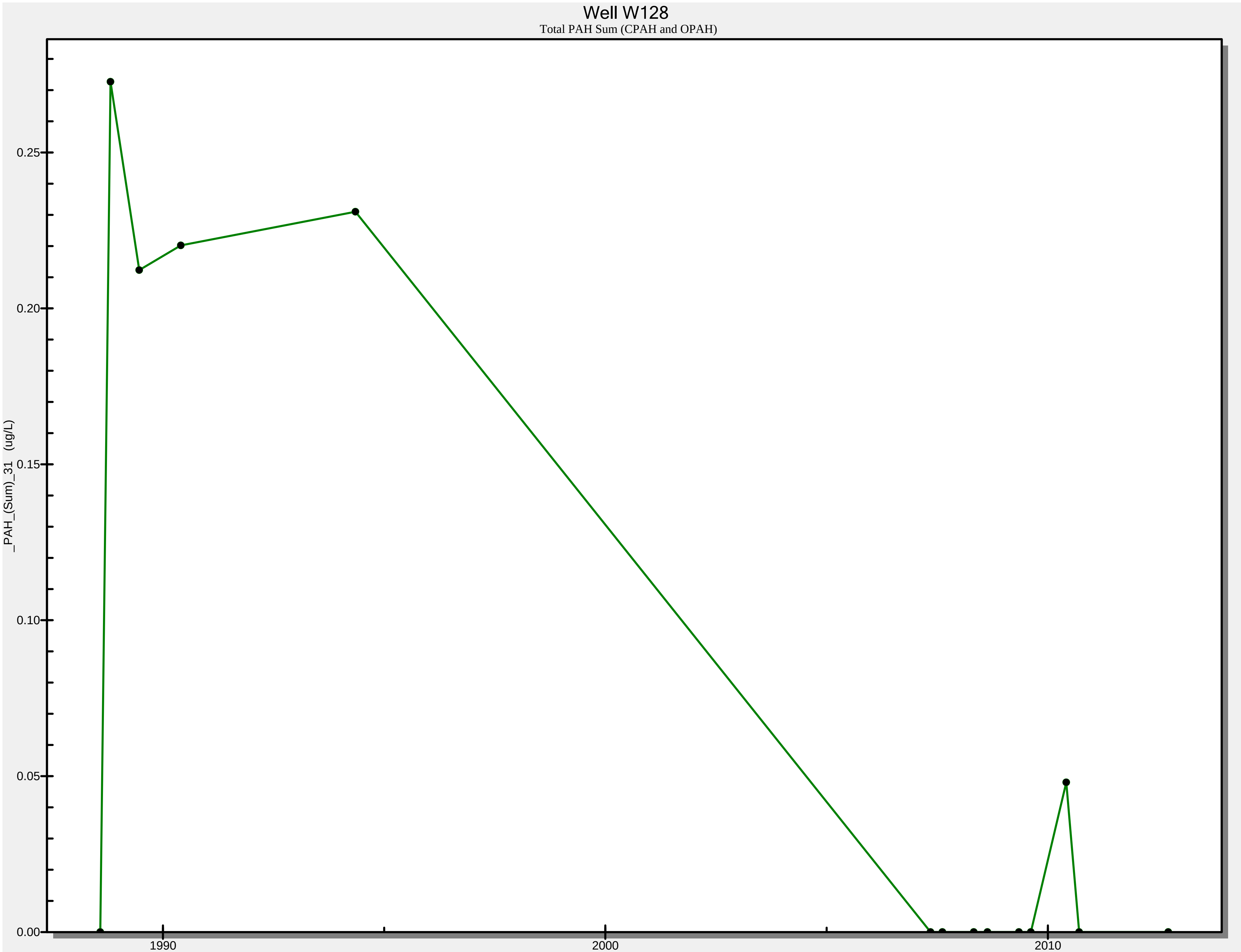
Well W120
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

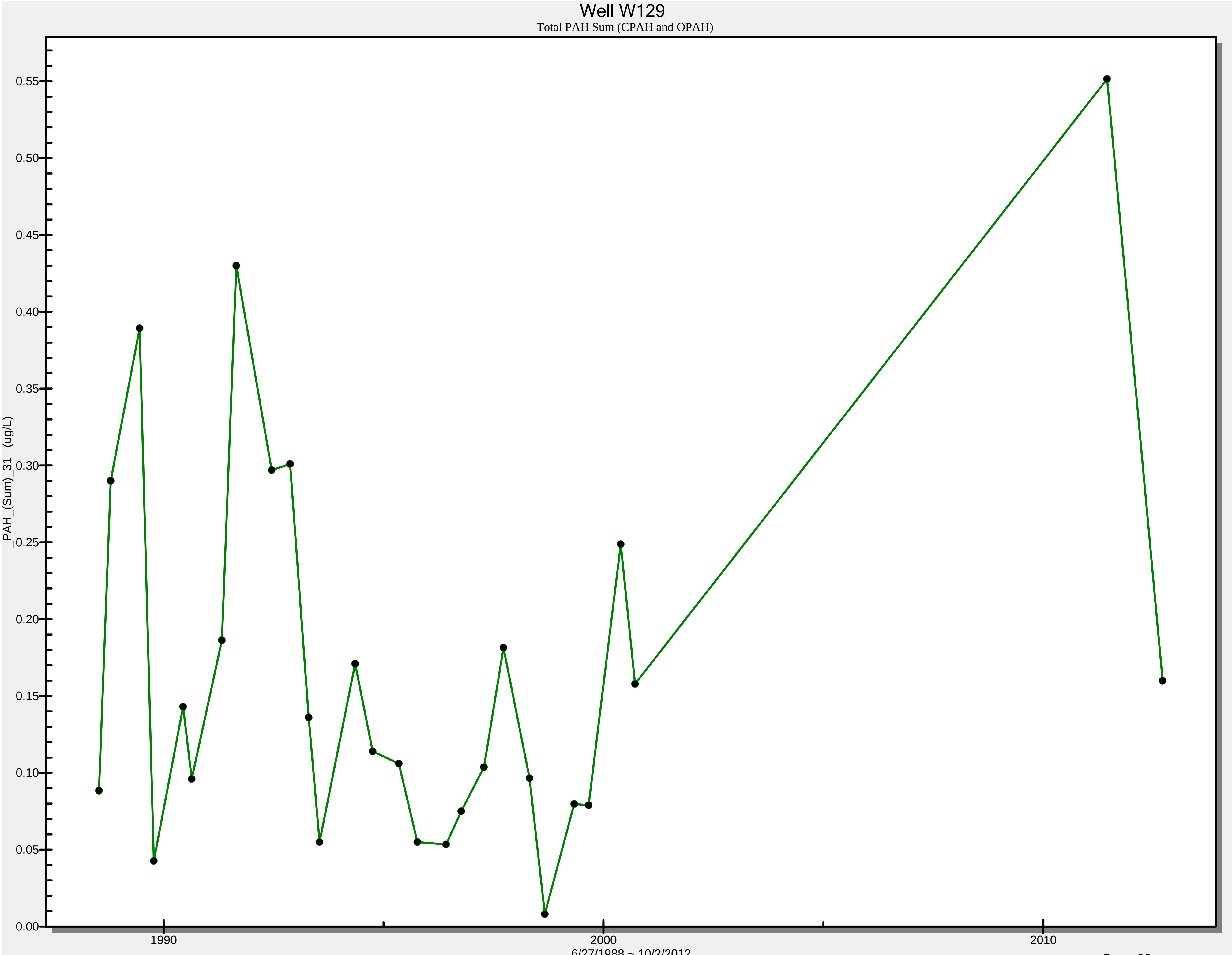

Well W121
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012



Well W122
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well W124
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
1995
2000
6/27/1988 ~ 10/2/2012

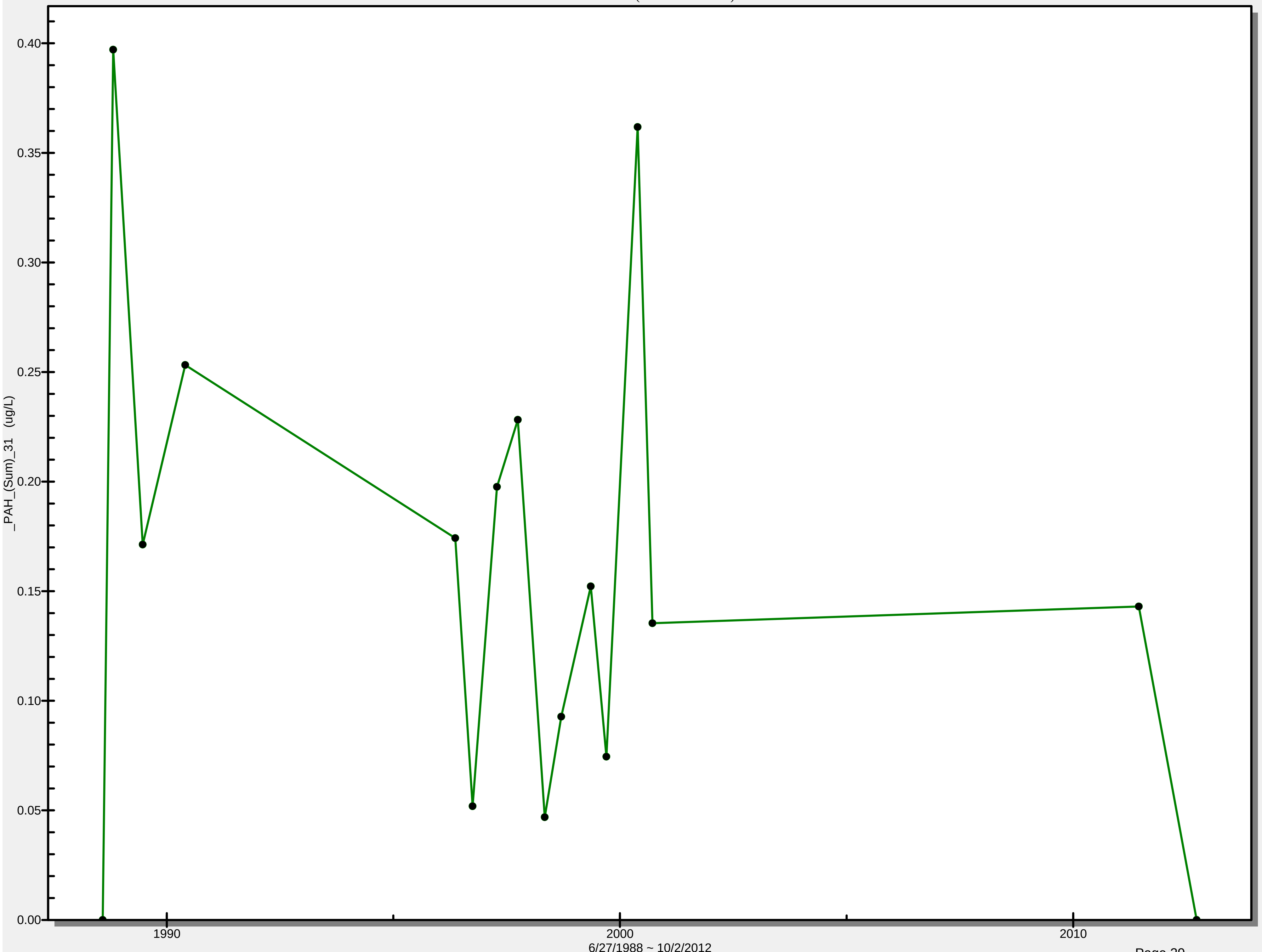

Well W128
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012

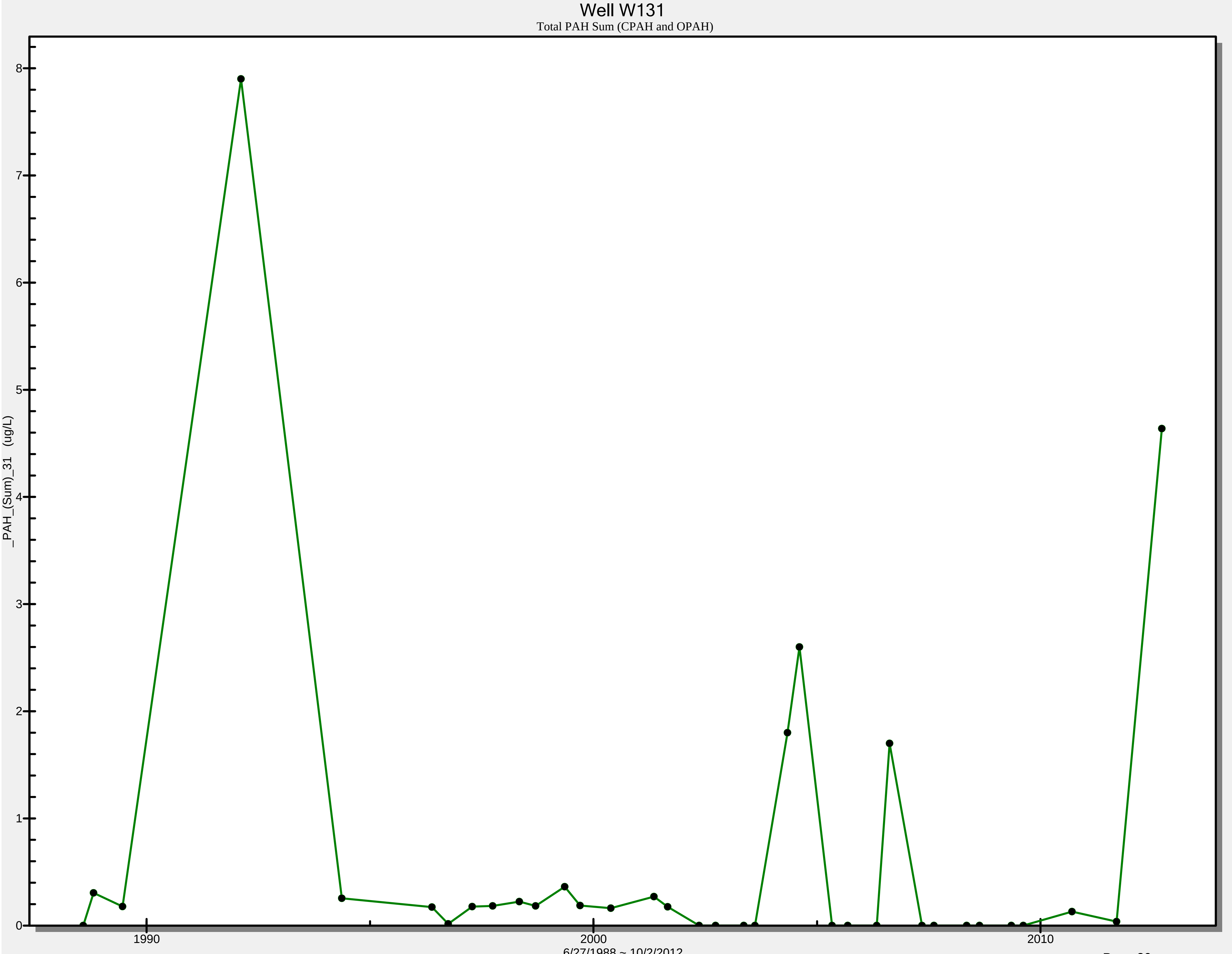


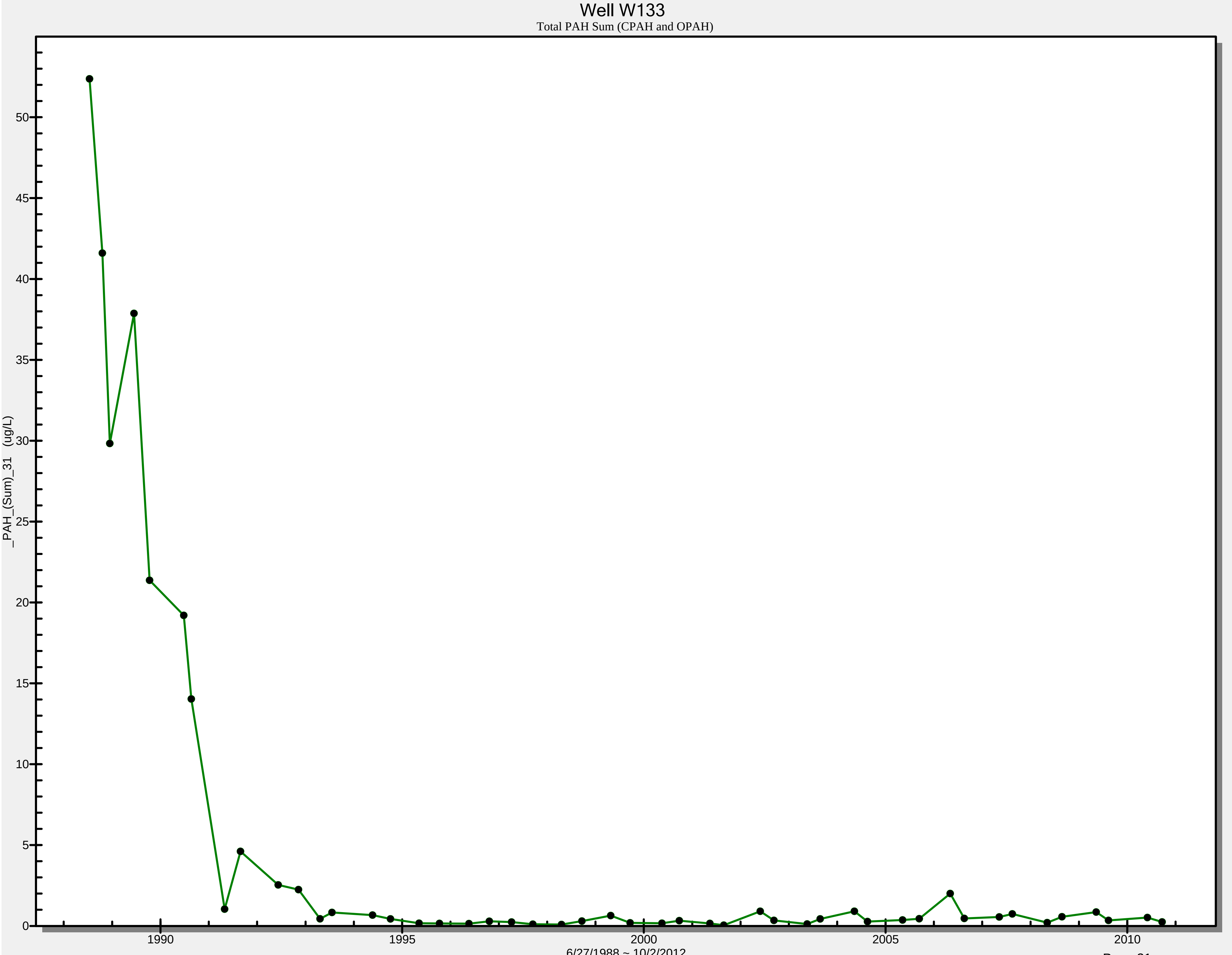
Well W129
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
1990
2000
2010
6/27/1988 ~ 10/2/2012

Well W130

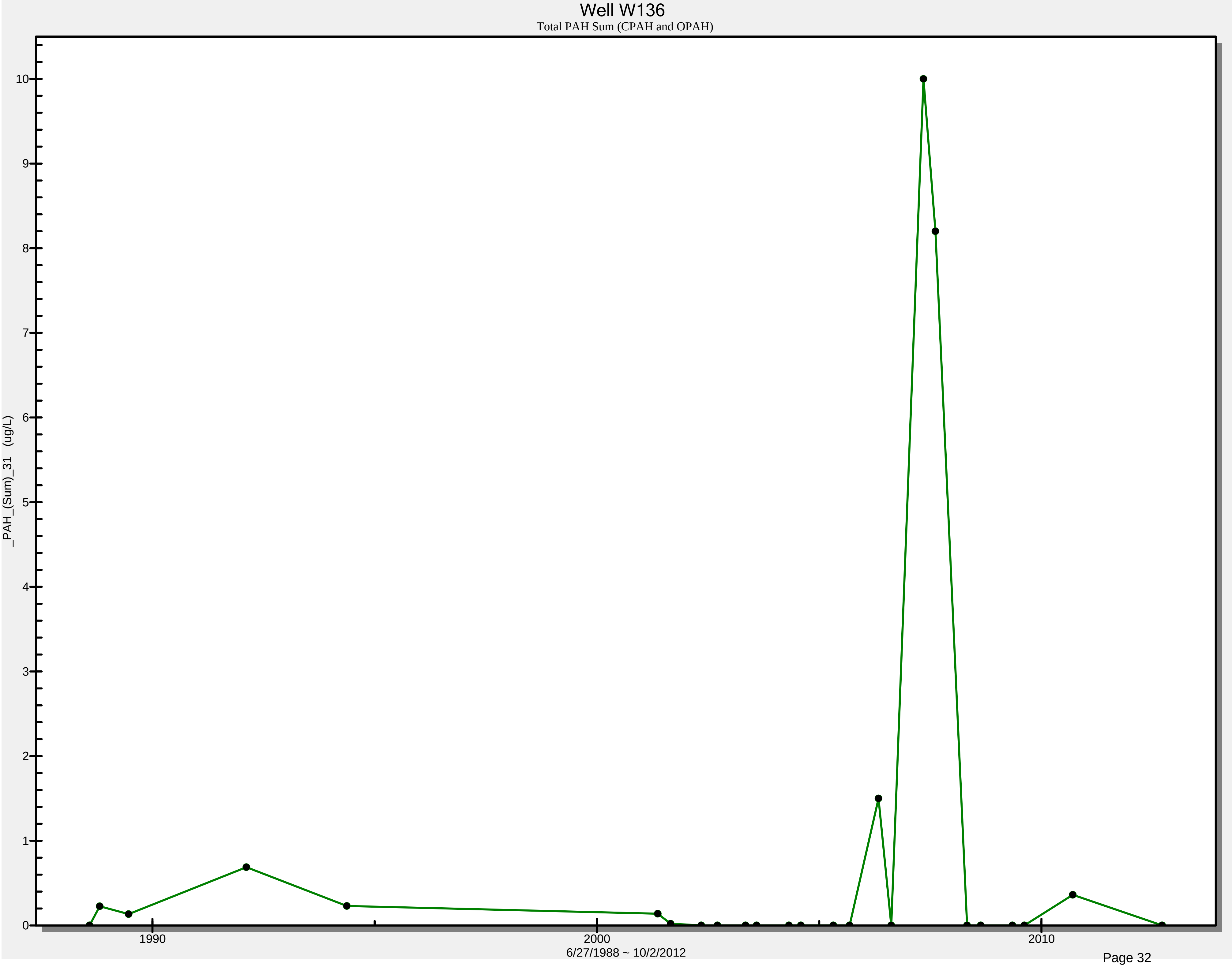
Total PAH Sum (CPAH and OPAH)



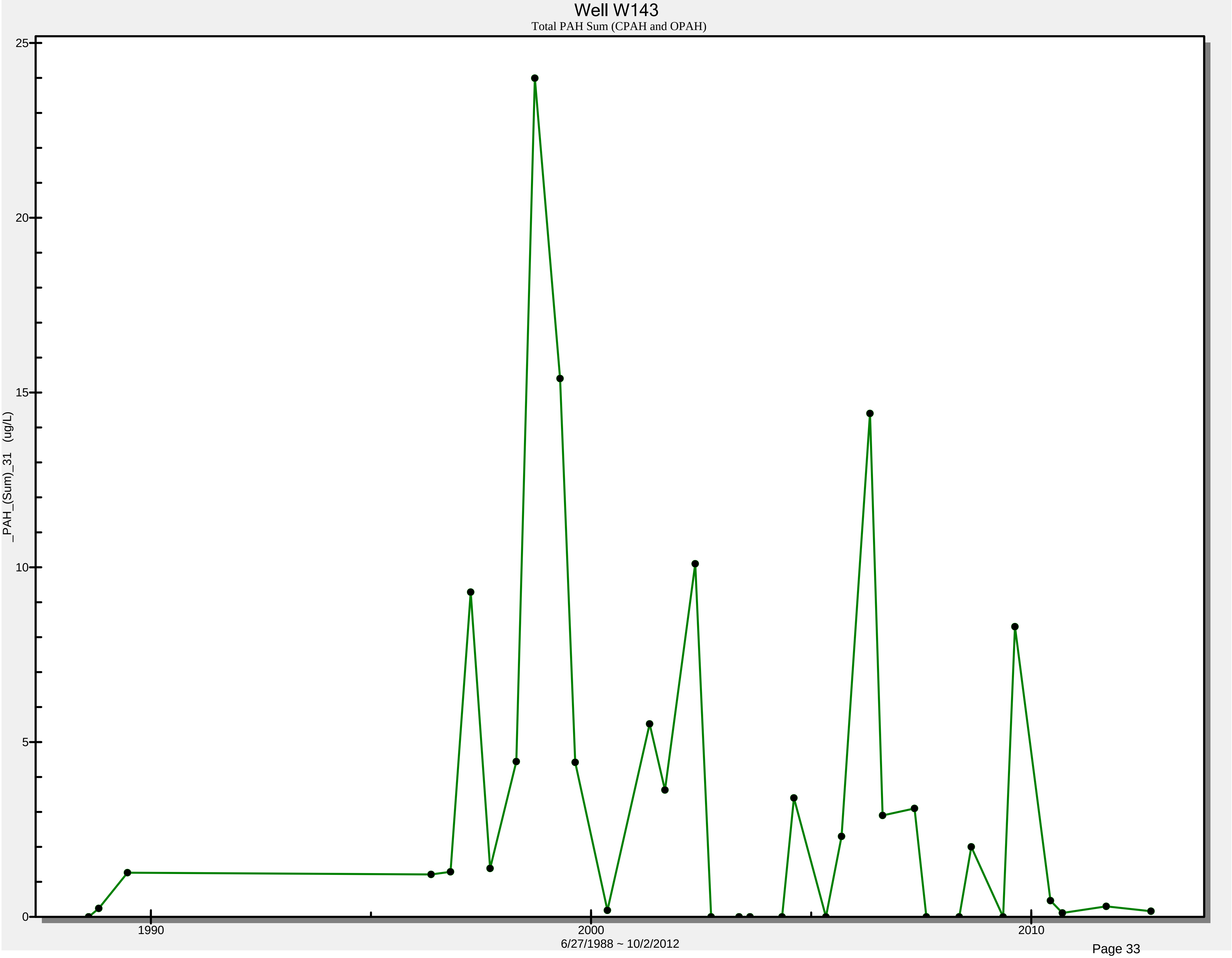

Well W131
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
1990
2000
2010
6/27/1988 ~ 10/2/2012



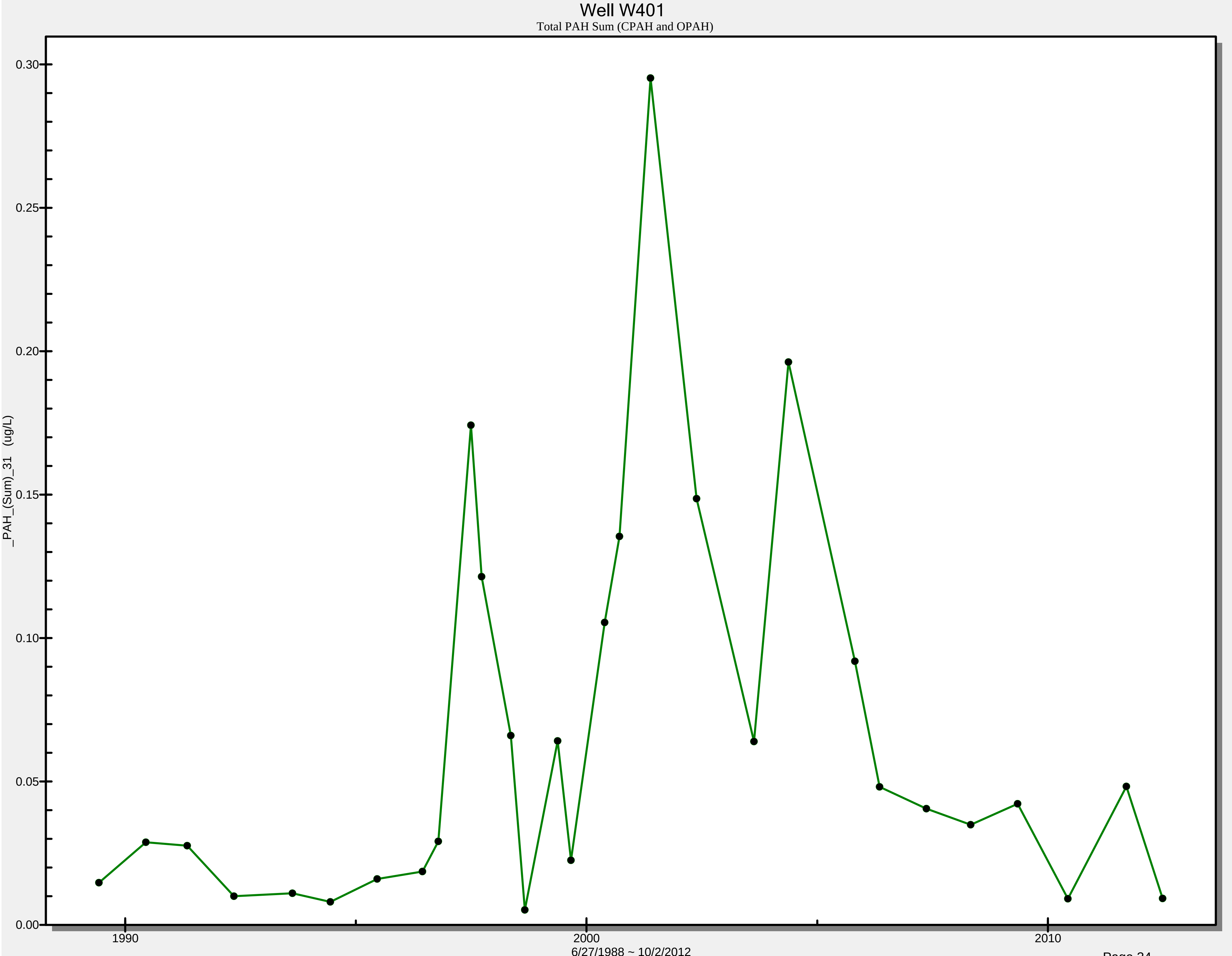
Well W133
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
5
10
15
20
25
30
35
40
45
50
1990
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012



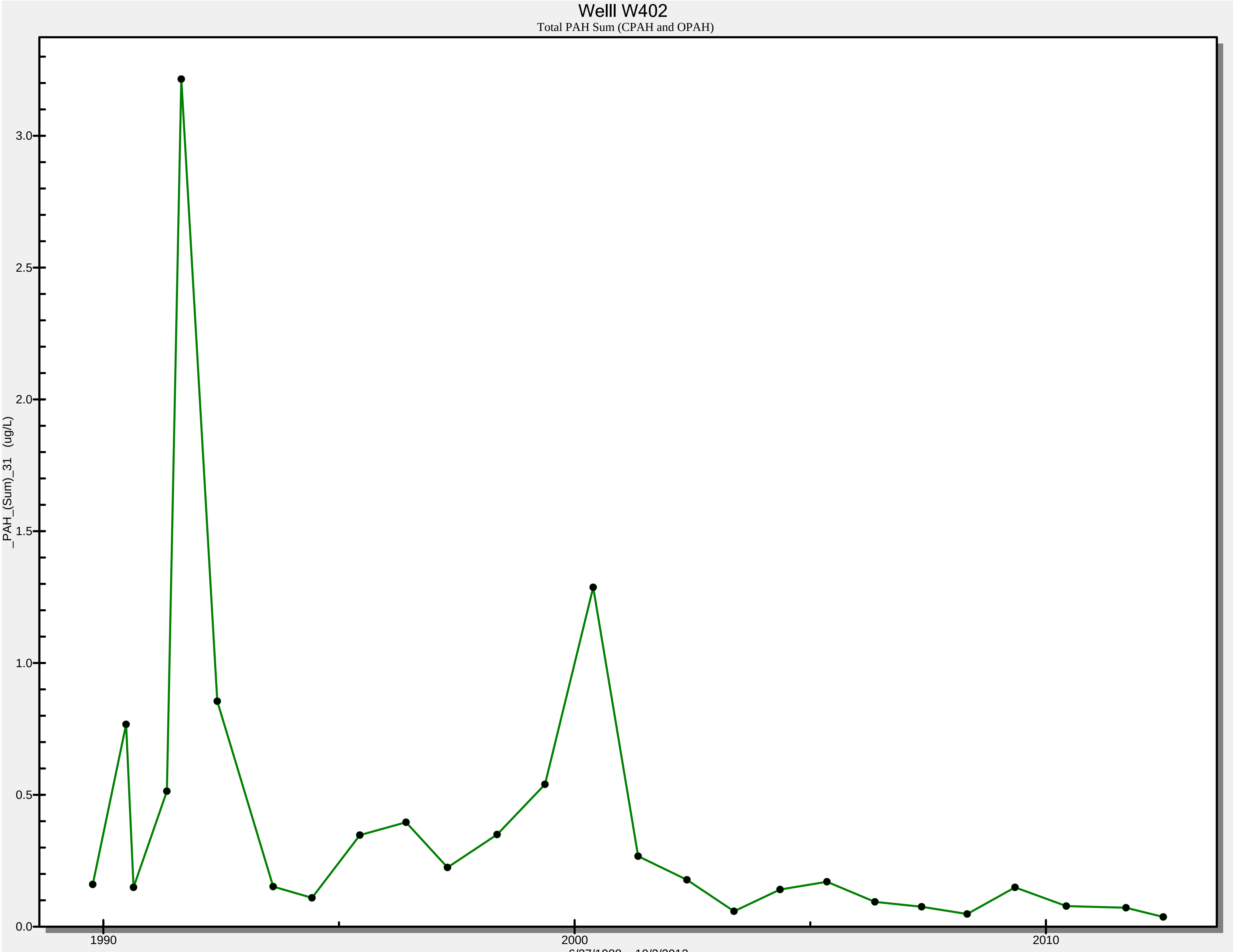
Well W136
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
9
10
1990
2000
2010
6/27/1988 ~ 10/2/2012



Well W143
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
25
20
15
10
5
0
1990
2000
2010
6/27/1988 ~ 10/2/2012



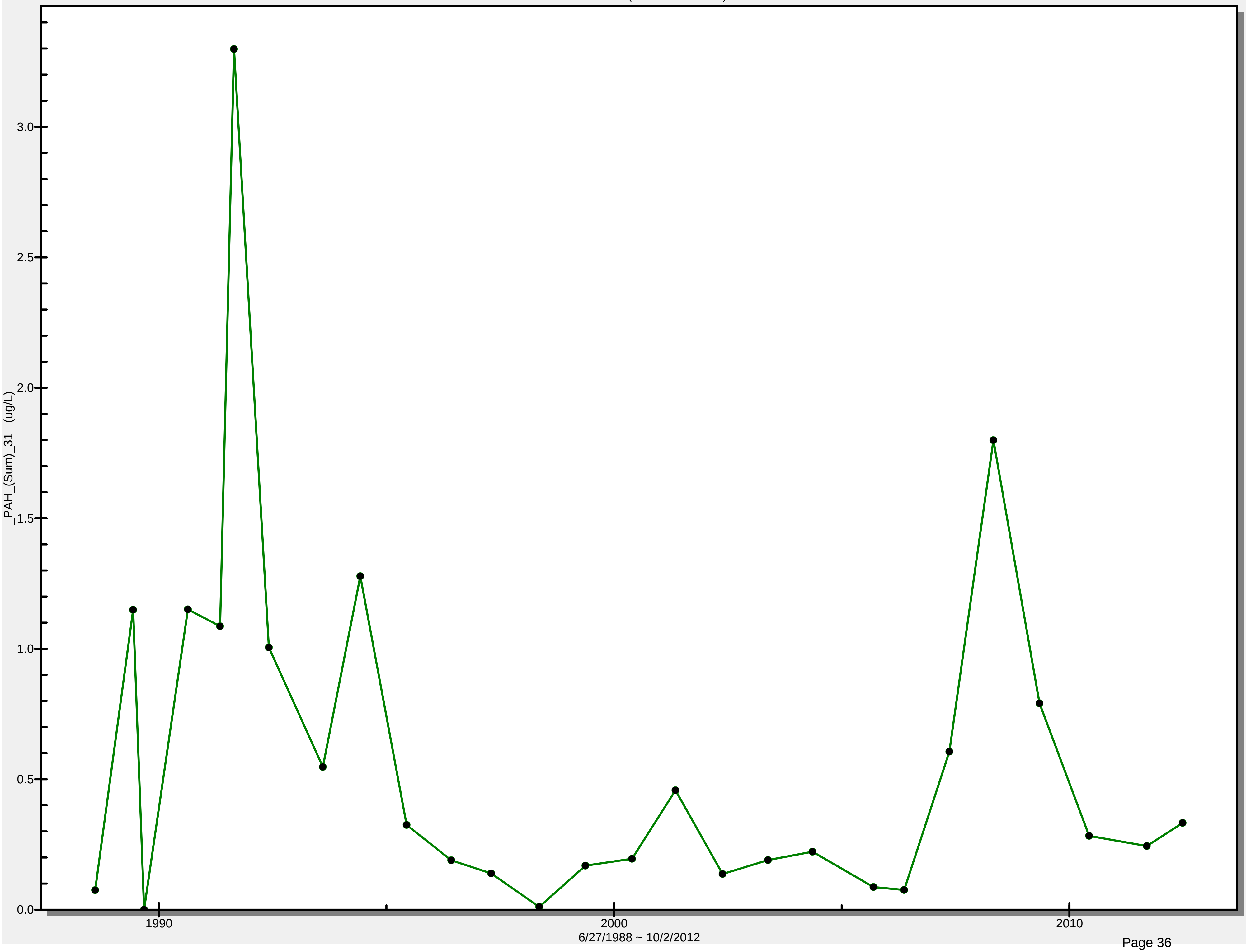
Well W401
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012

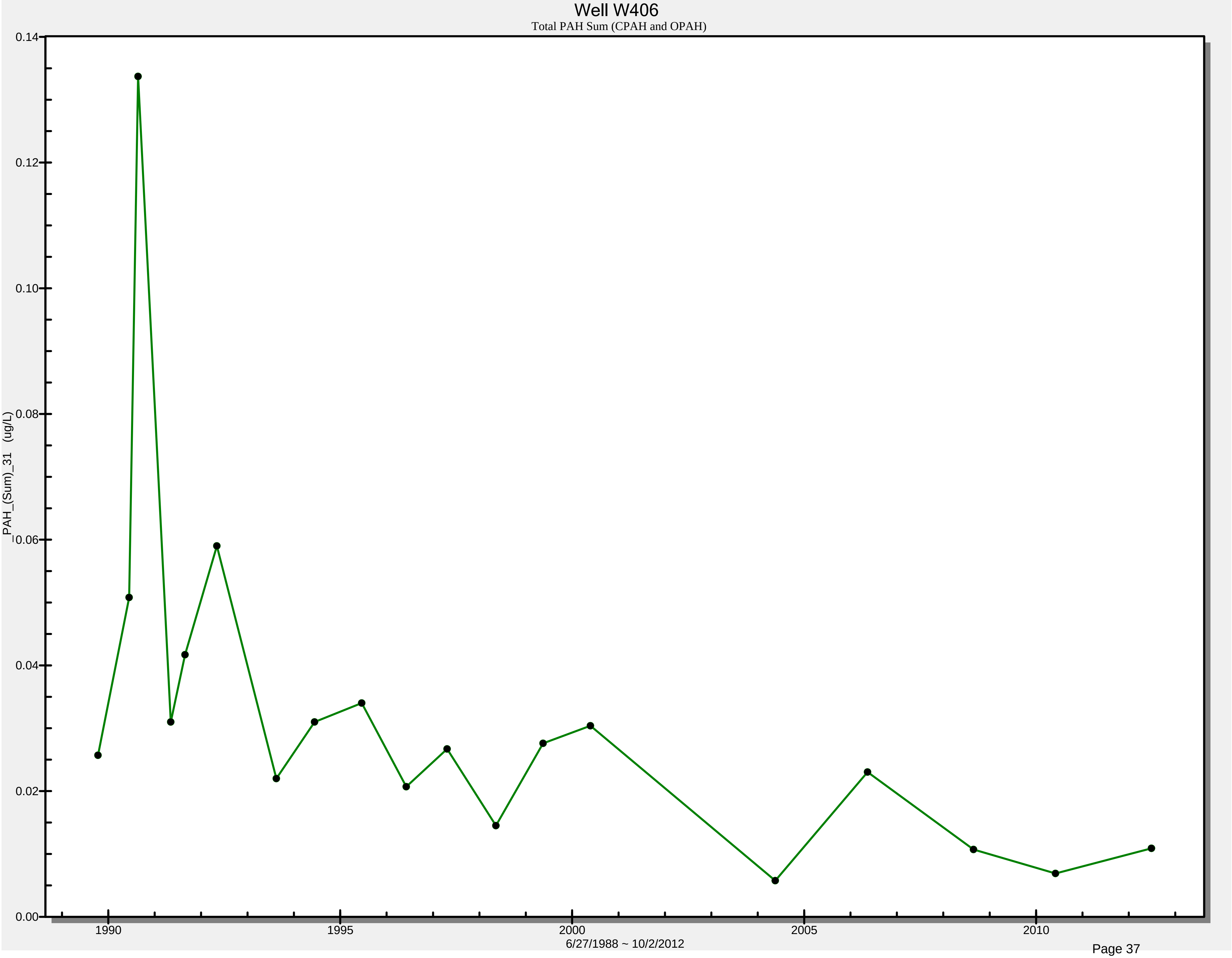


Welll W402
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1990
2000
2010
6/27/1988 ~ 10/2/2012

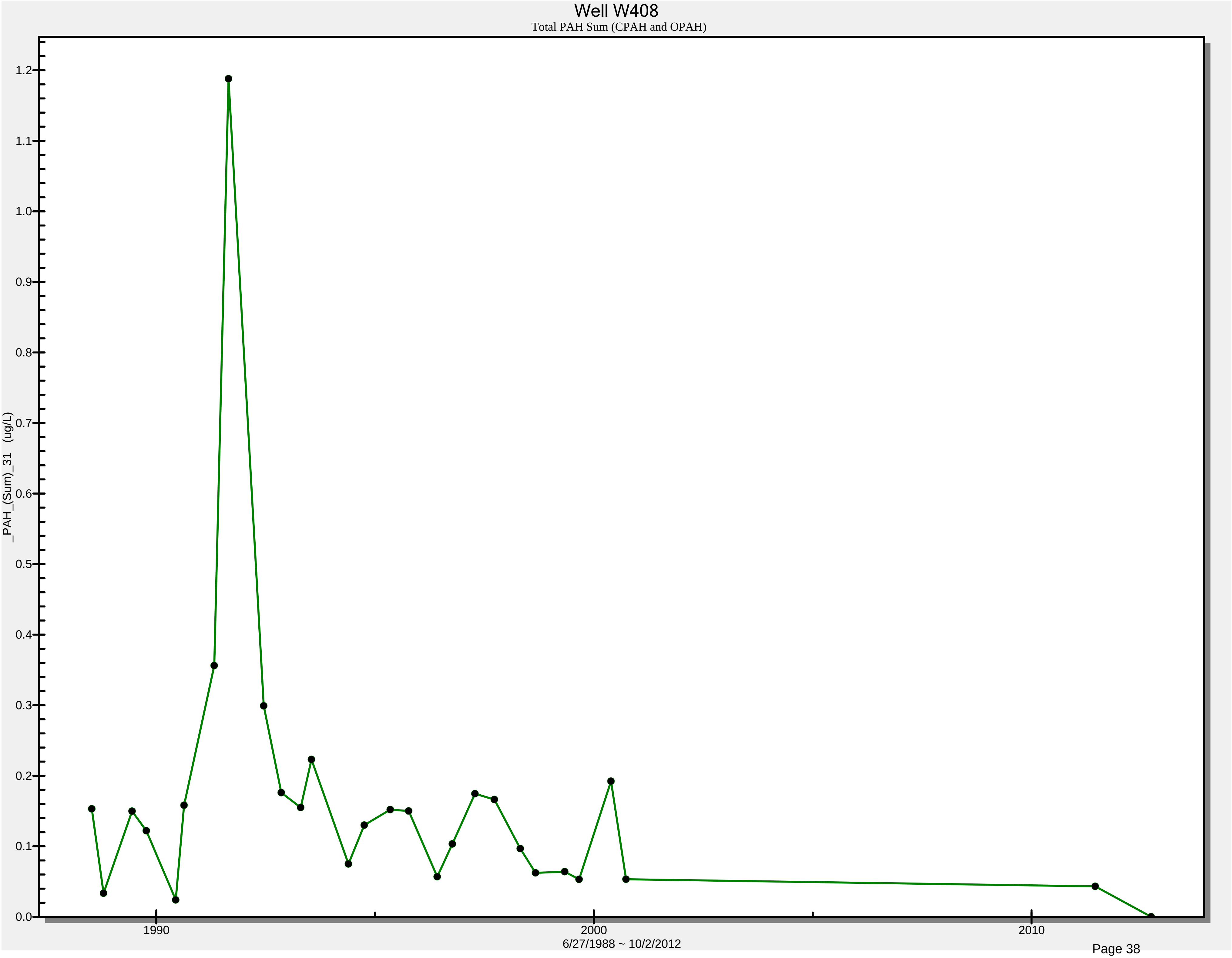
Well W403

Total PAH Sum (CPAH and OPAH)



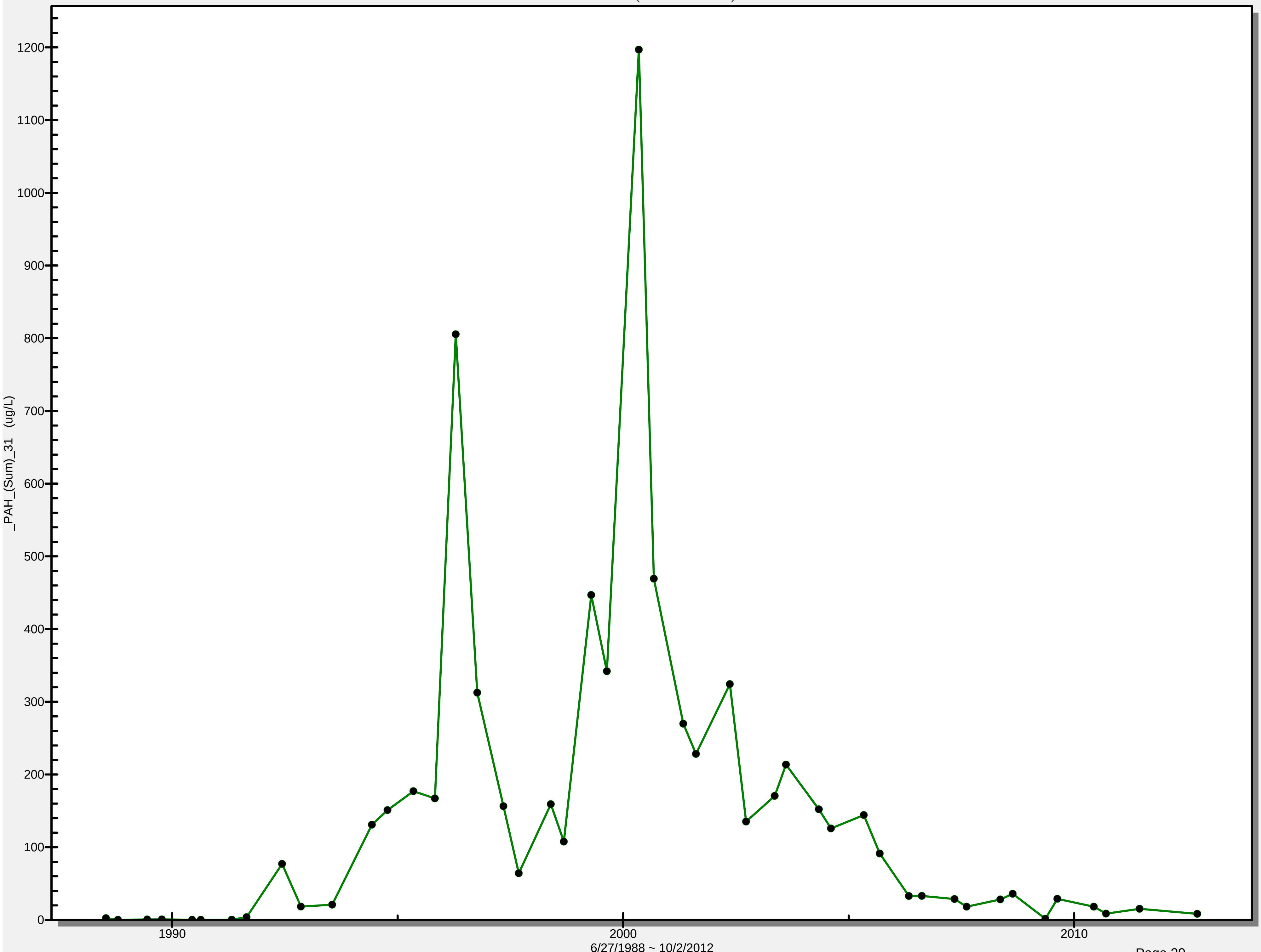


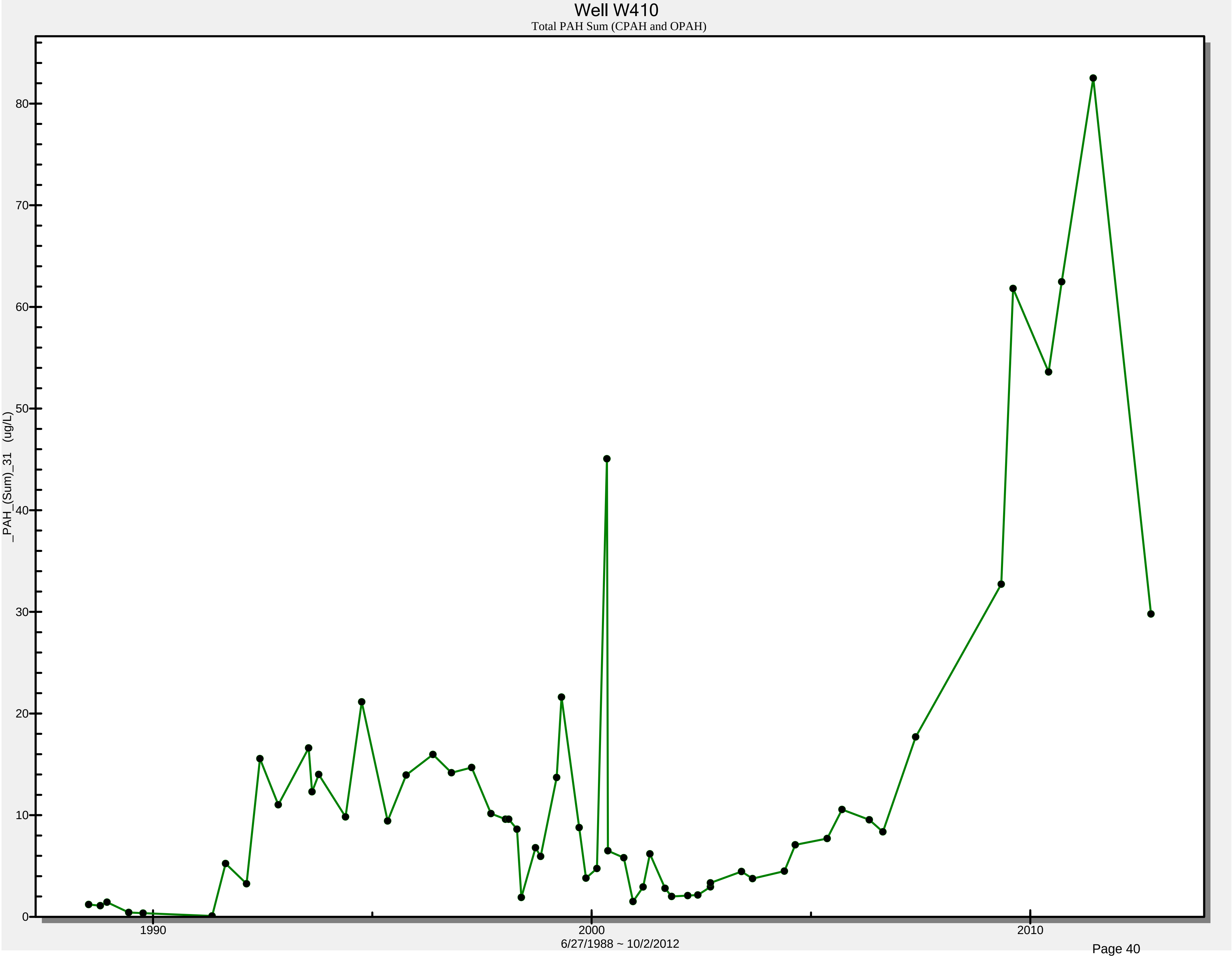
Well W406
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1990
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012


Well W408
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012

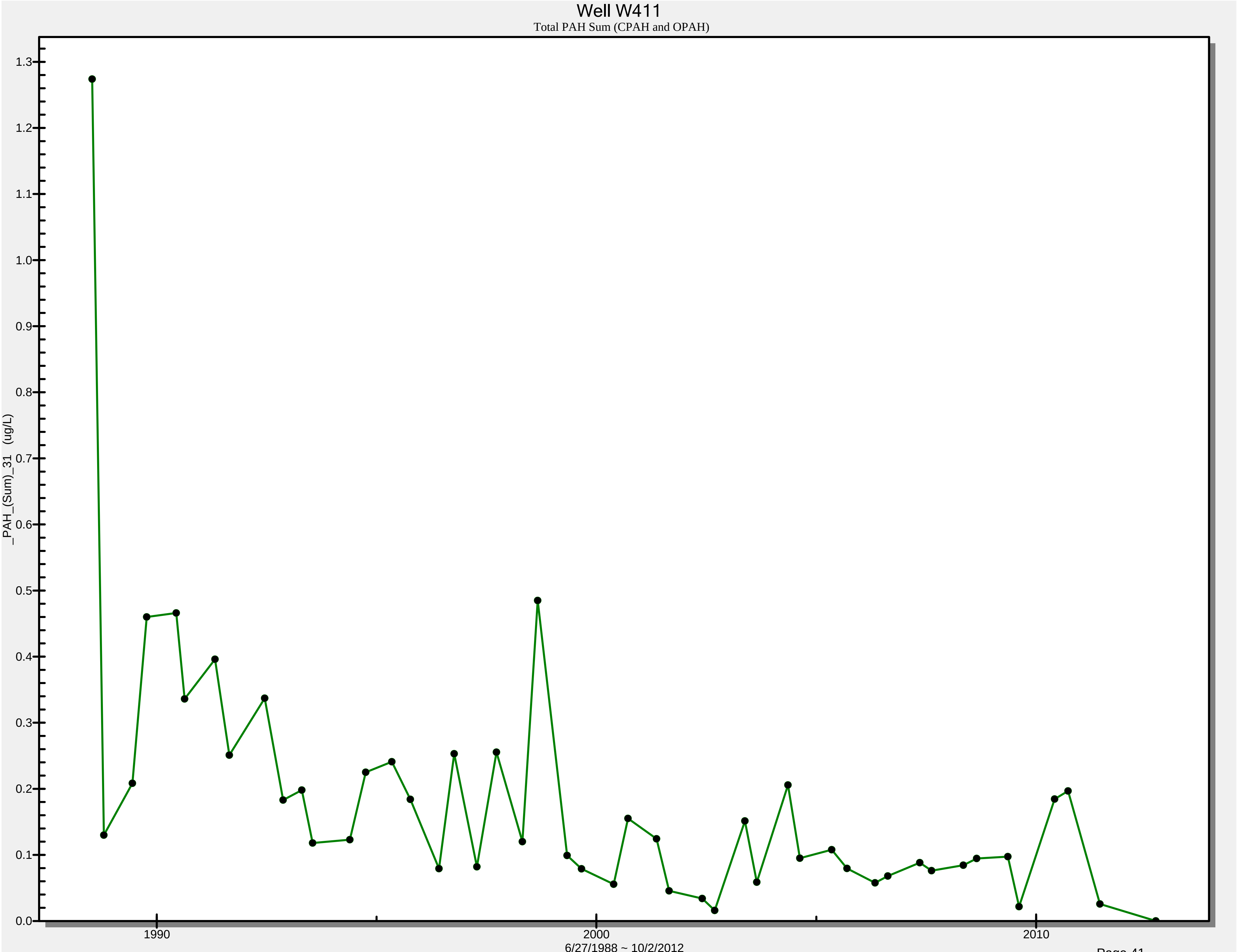
Well W409

Total PAH Sum (CPAH and OPAH)

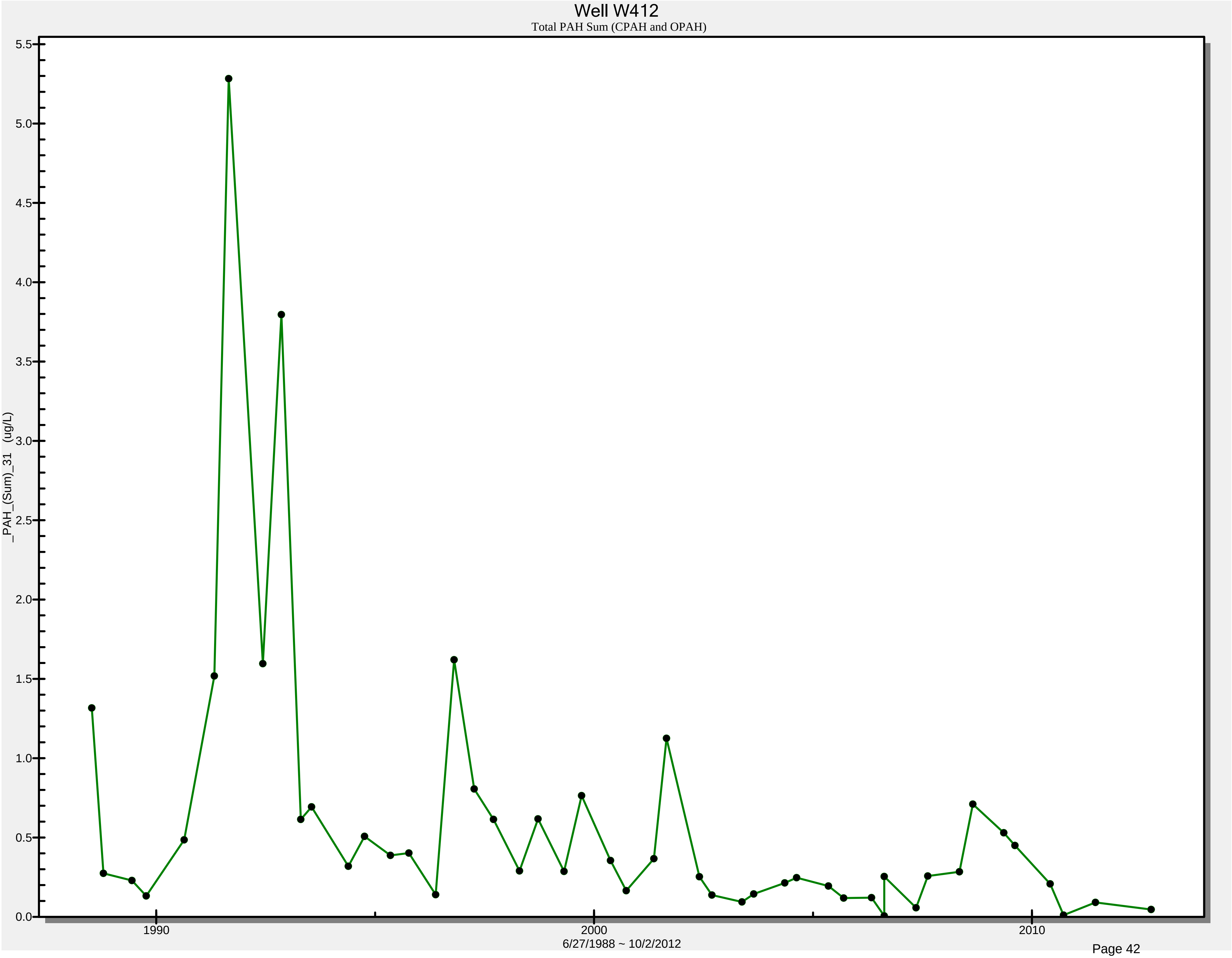




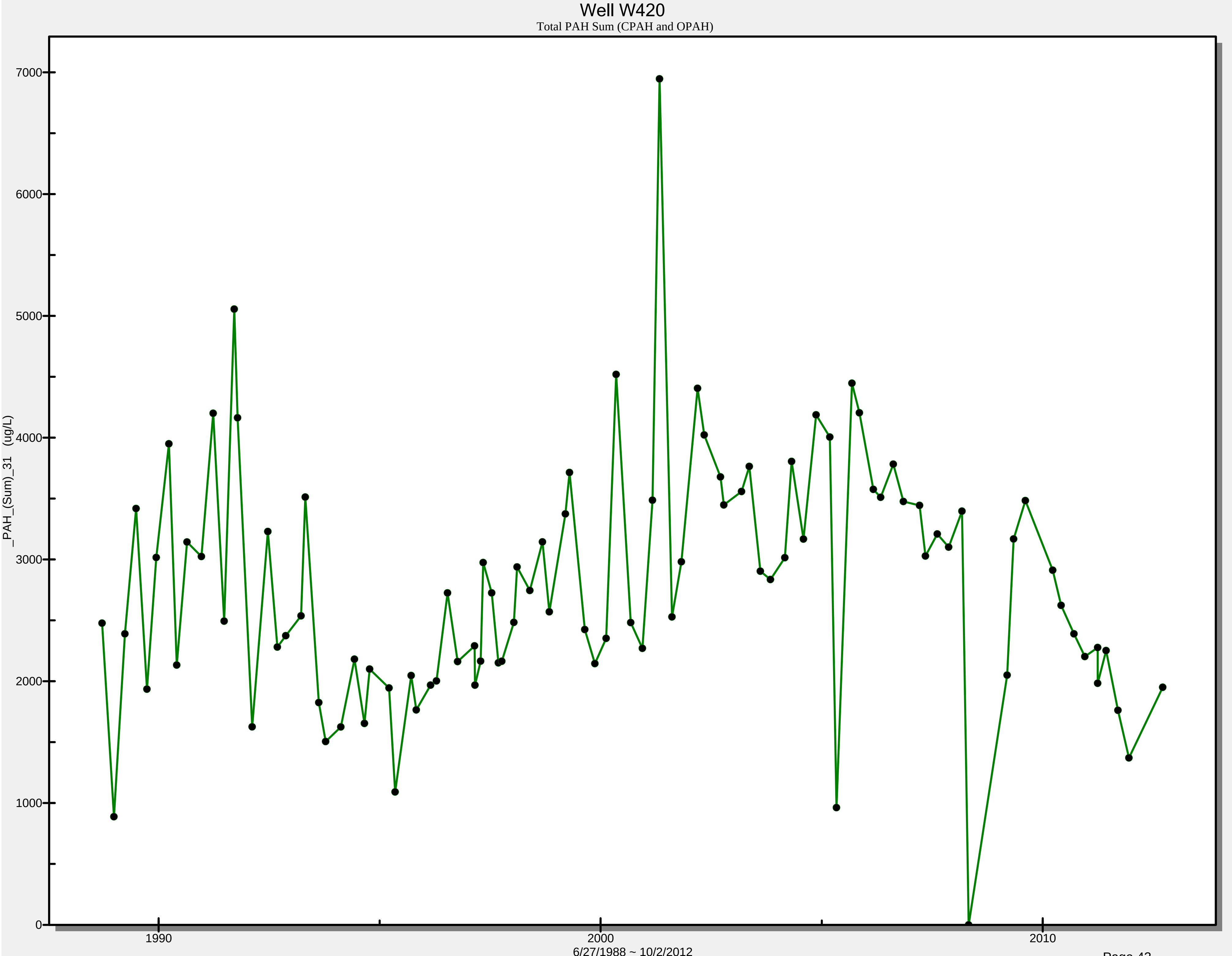
Well W410
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
10
20
30
40
50
60
70
80
1990
2000
2010
6/27/1988 ~ 10/2/2012

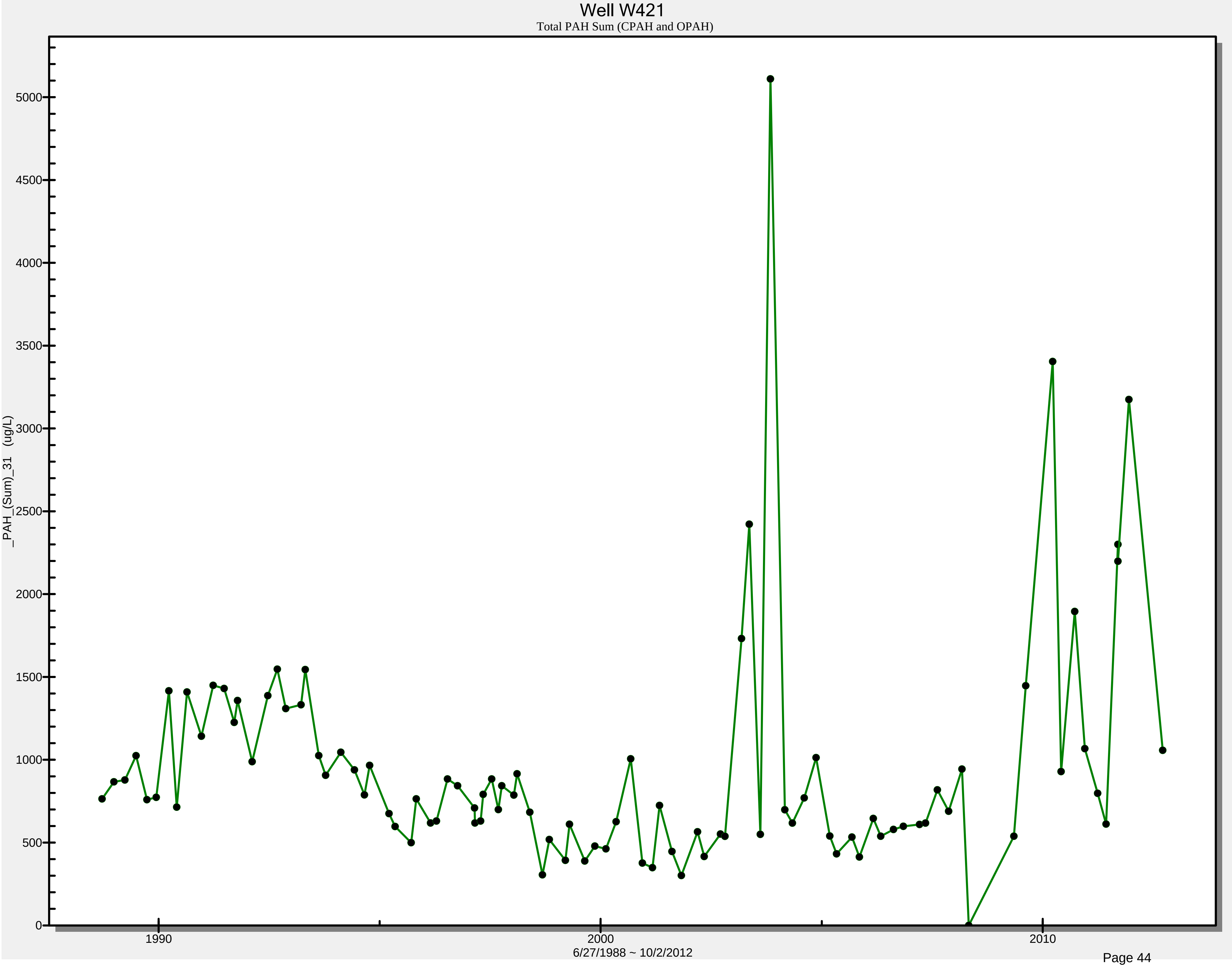


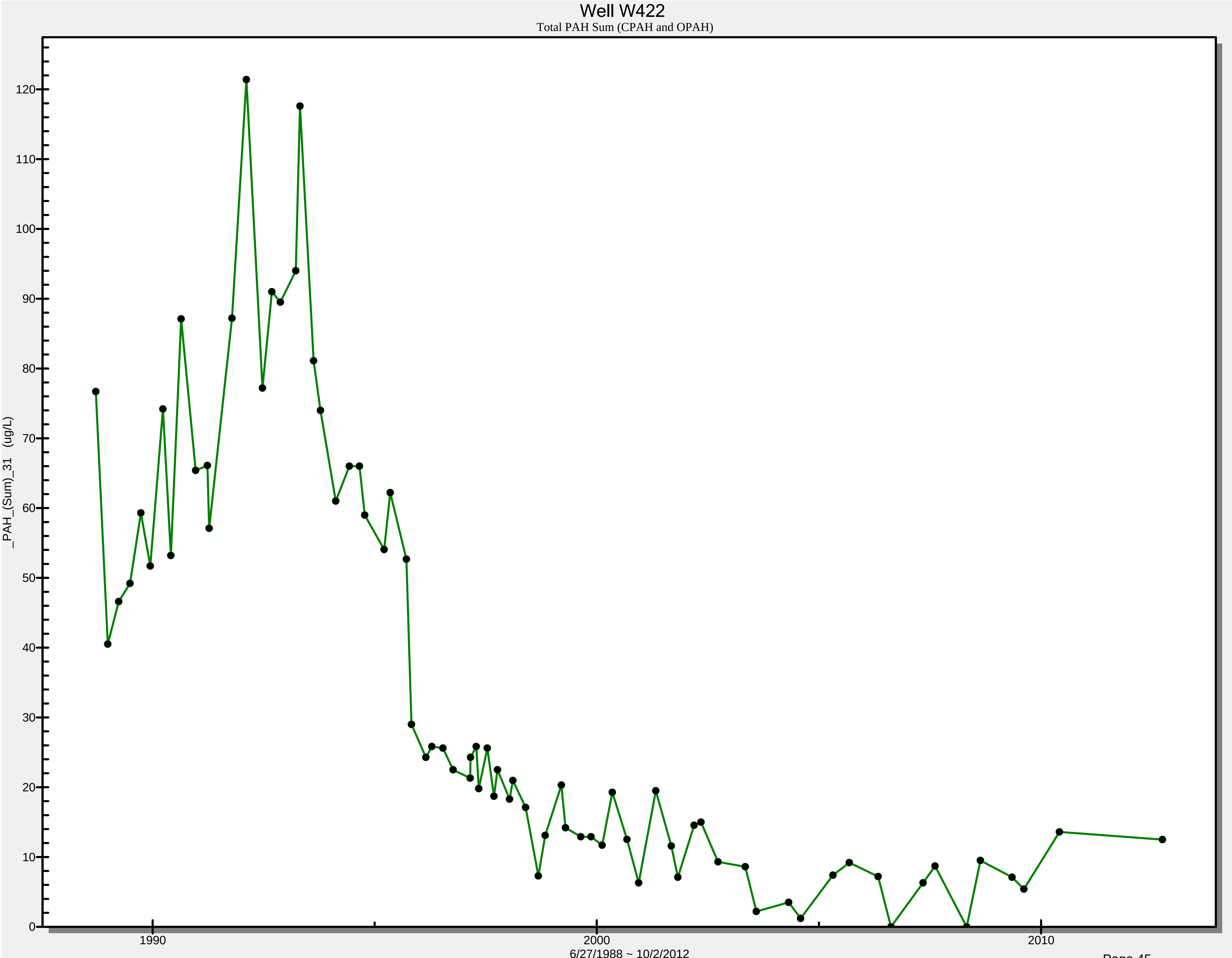
Well W411
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012



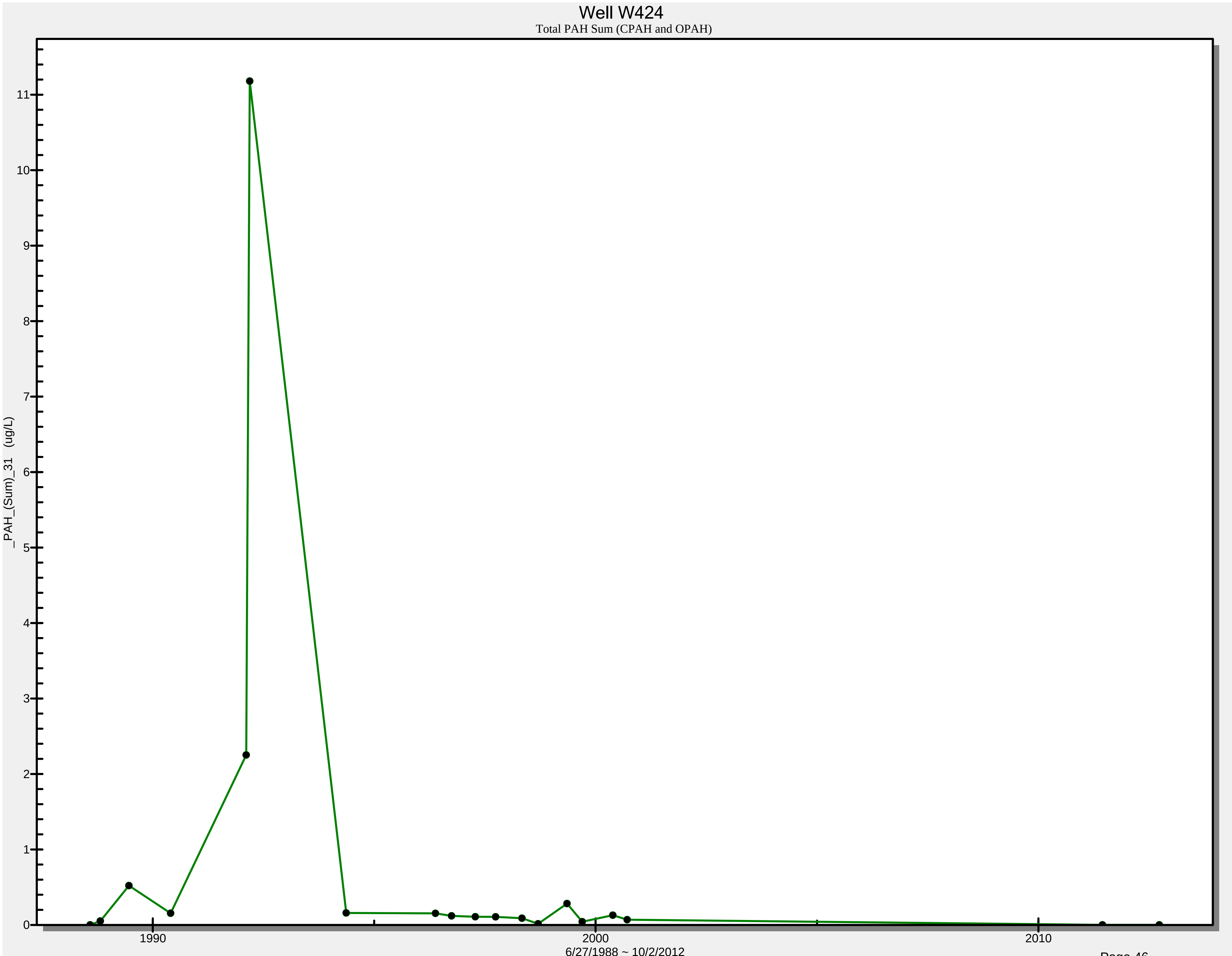
Well W412
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012

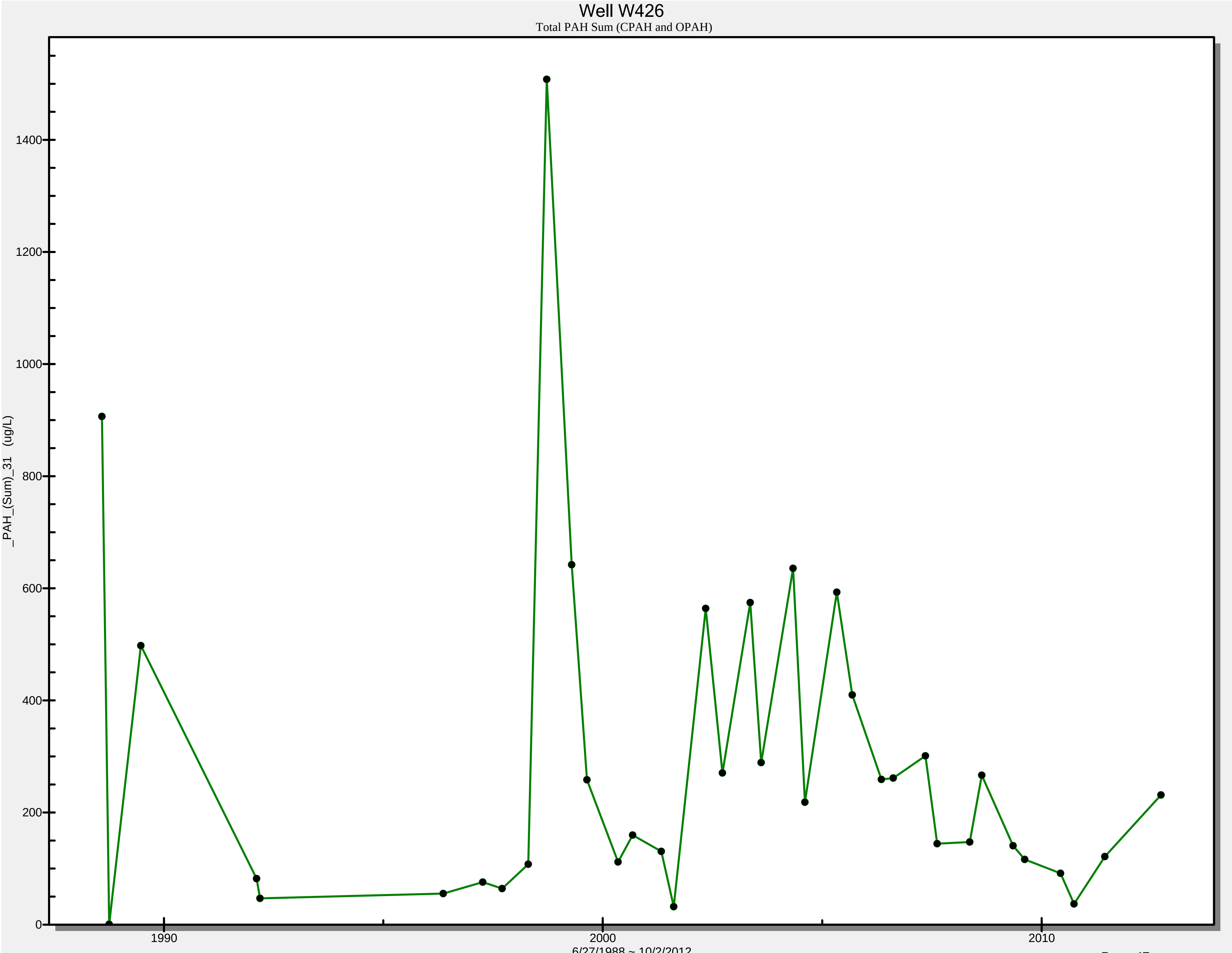

Well W420
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
7000
6000
5000
4000
3000
2000
1000
0
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well W421
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1990
2000
2010
6/27/1988 ~ 10/2/2012



Well W422
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
10
20
30
40
50
60
70
80
90
100
110
120
1990
2000
2010
6/27/1988 ~ 10/2/2012

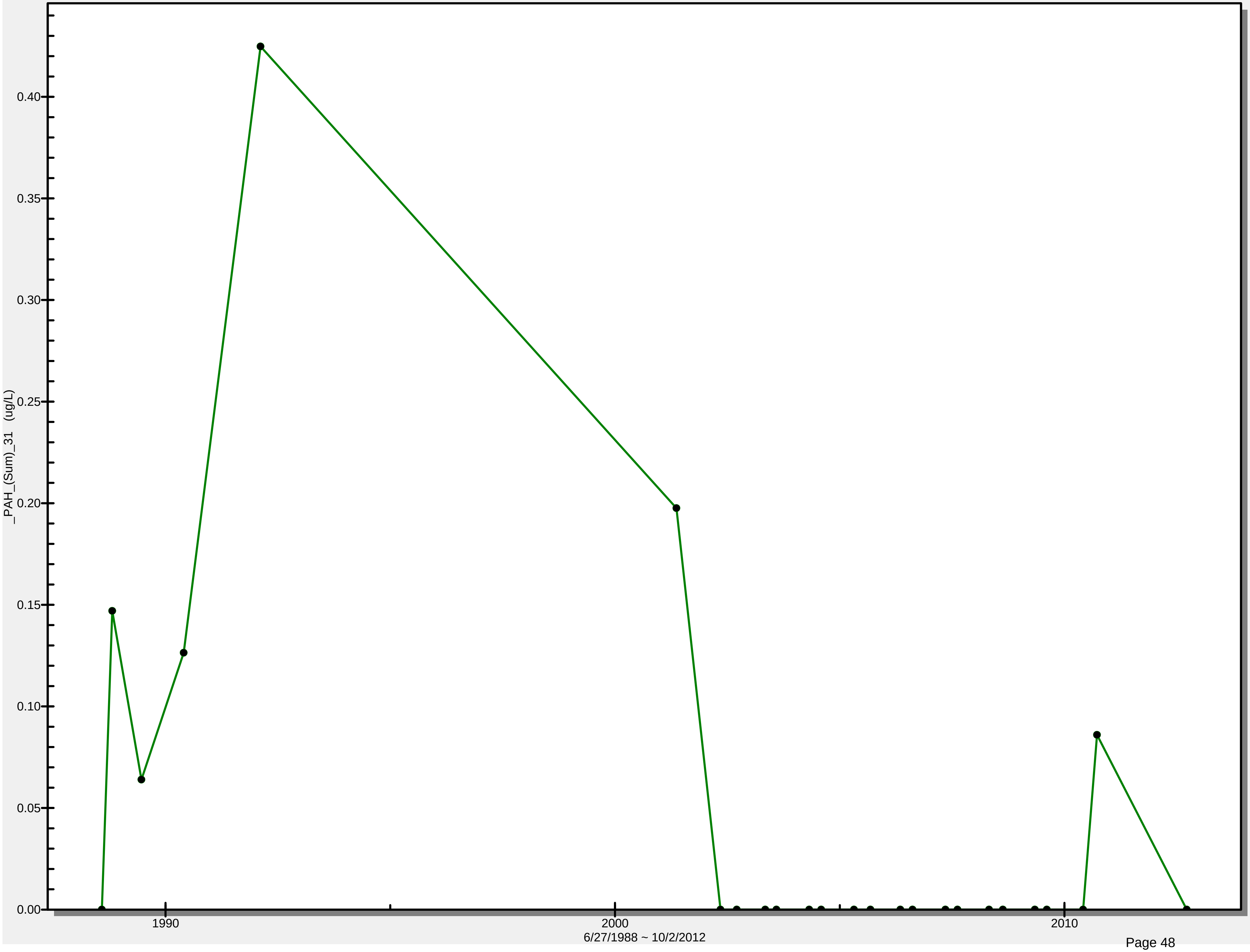

Well W424
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
9
10
11
1990
2000
2010
6/27/1988 ~ 10/2/2012

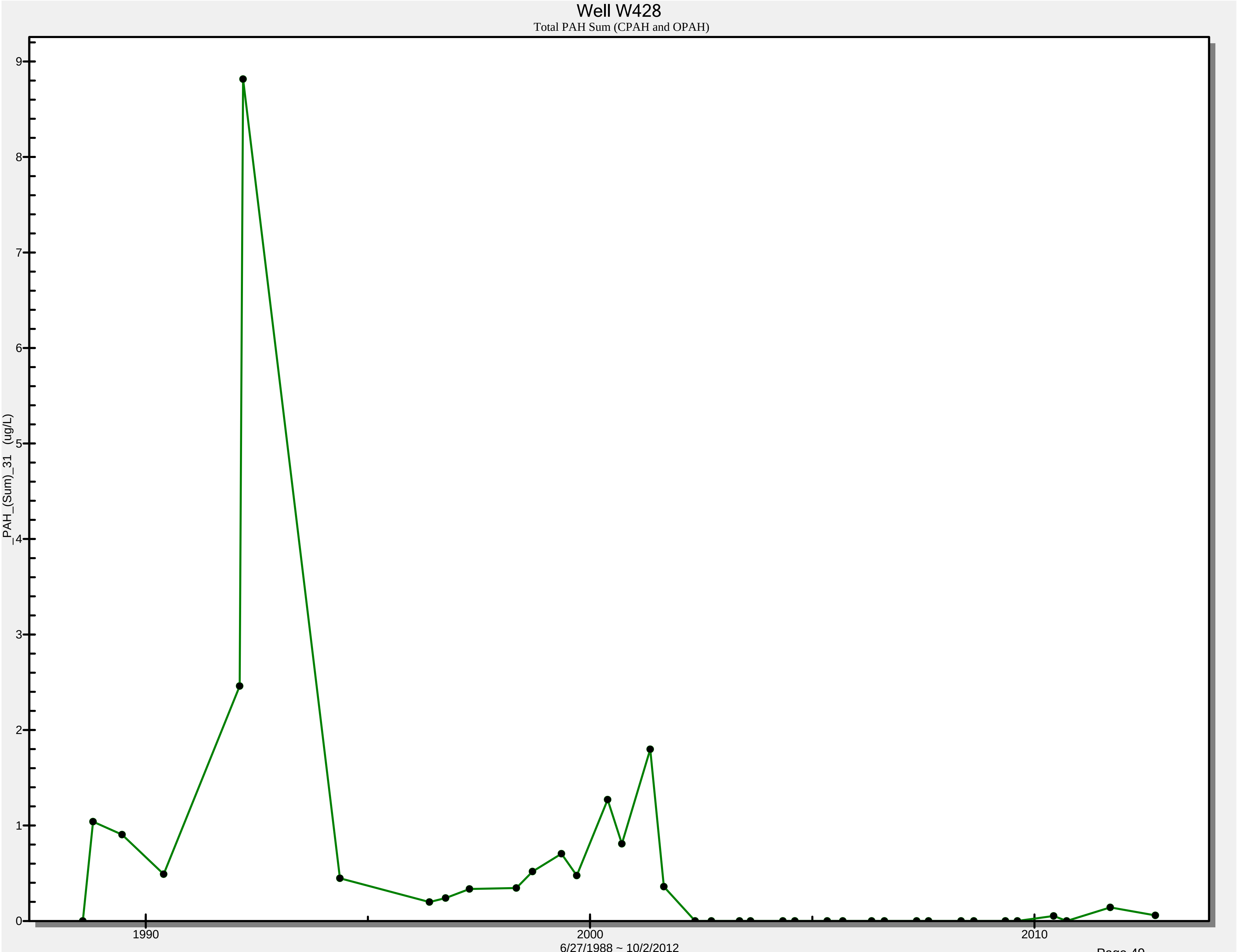


Well W426
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
200
400
600
800
1000
1200
1400
1990
2000
2010
6/27/1988 ~ 10/2/2012

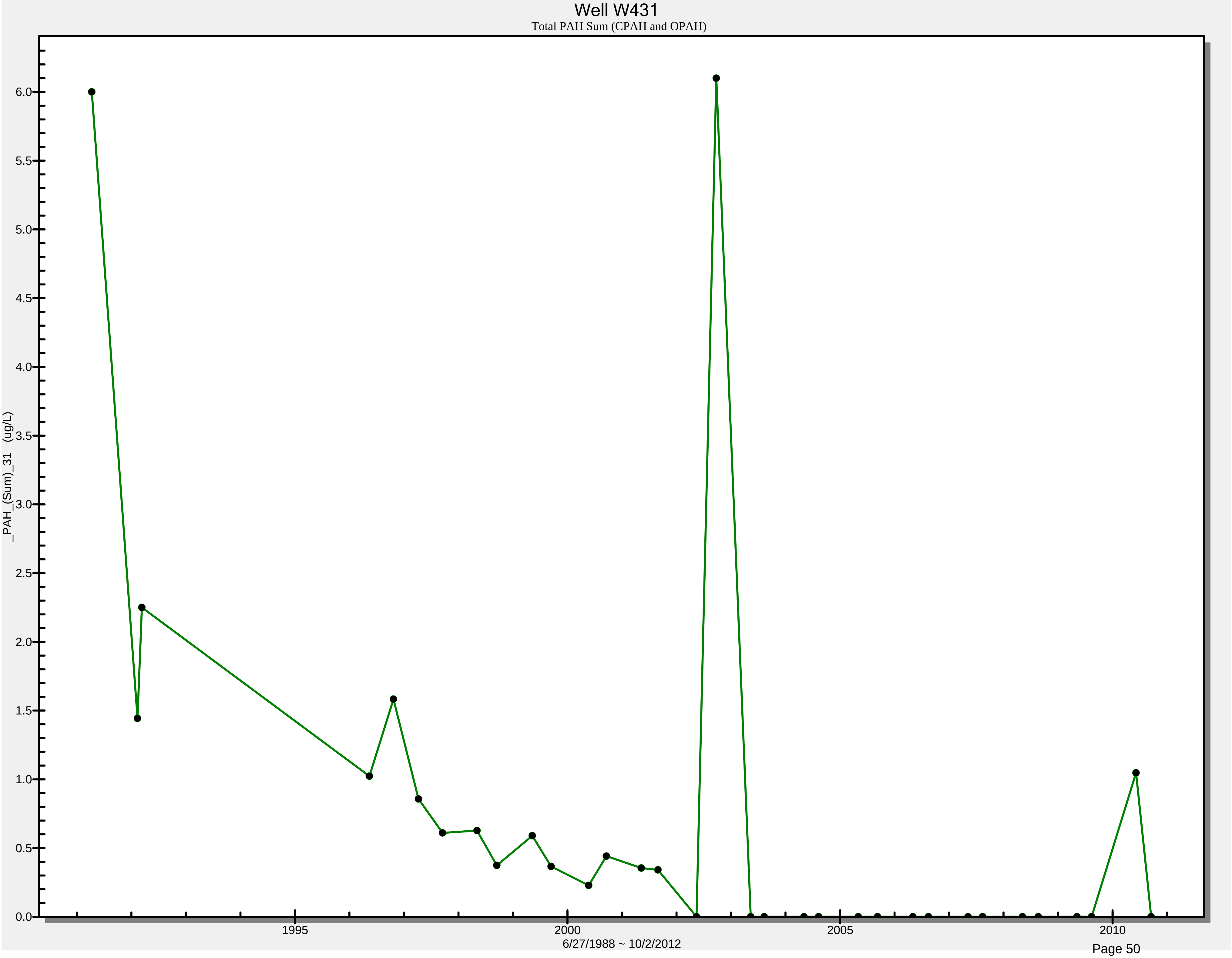
Well W427

Total PAH Sum (CPAH and OPAH)

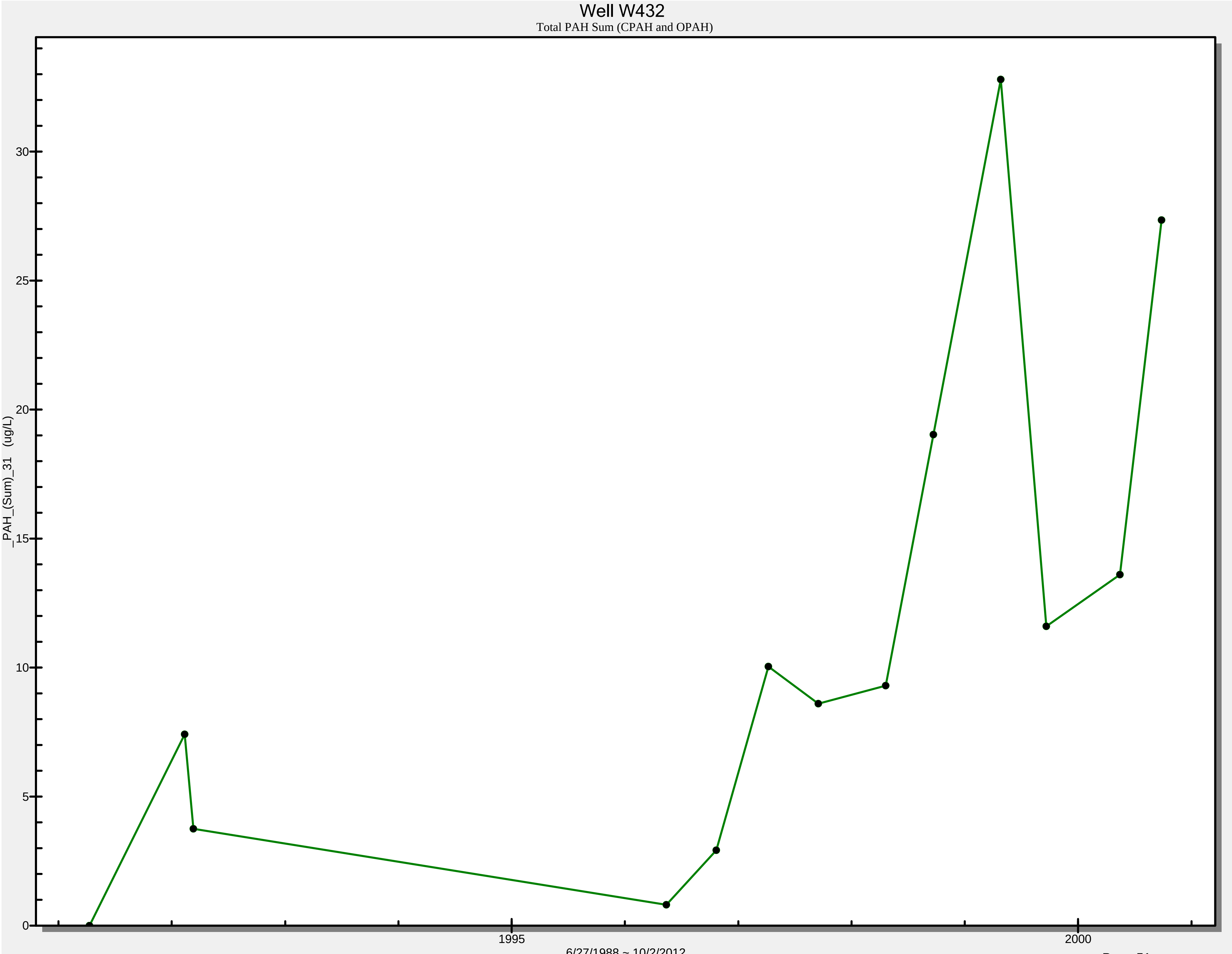




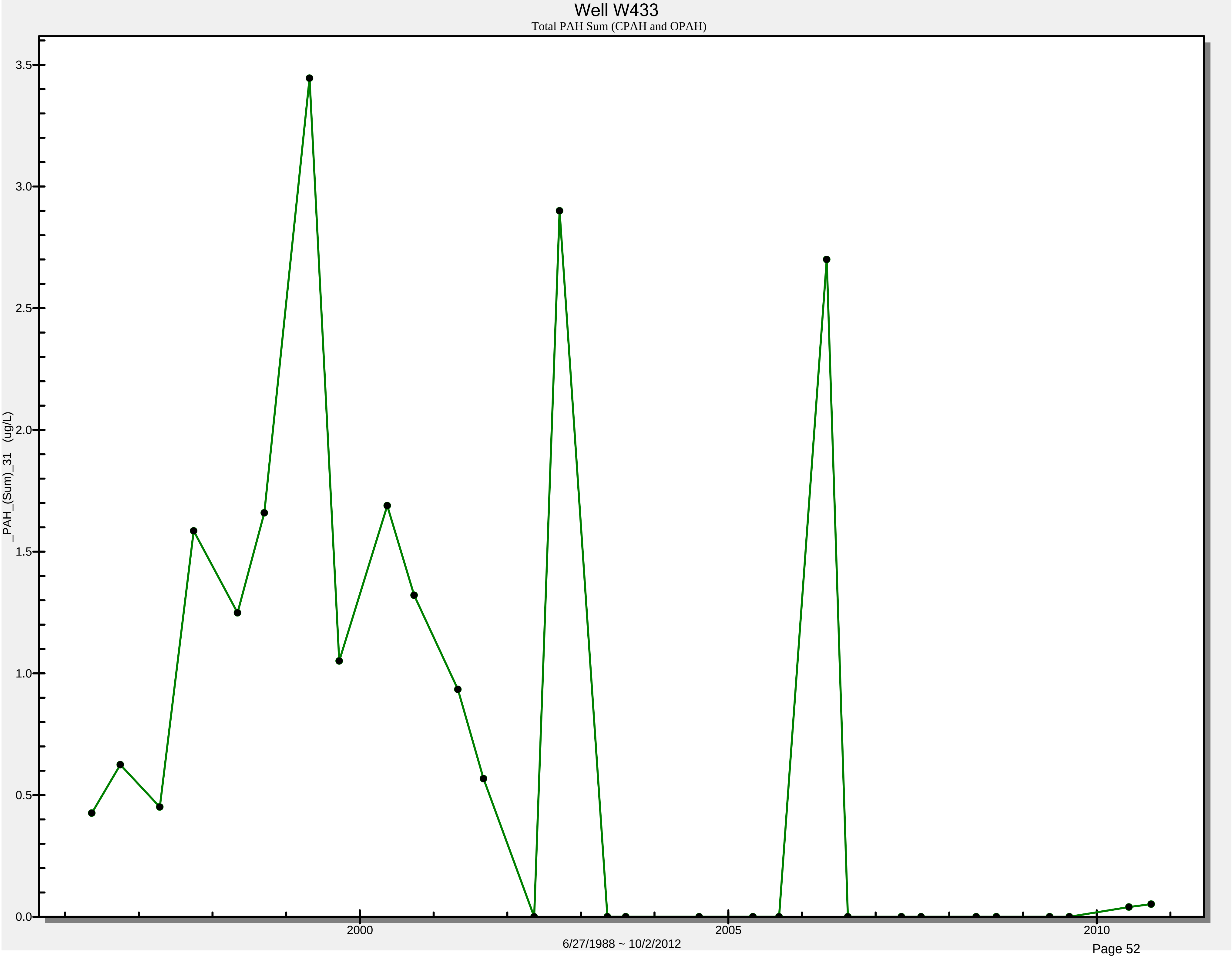
Well W428
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
9
1990
2000
2010
6/27/1988 ~ 10/2/2012

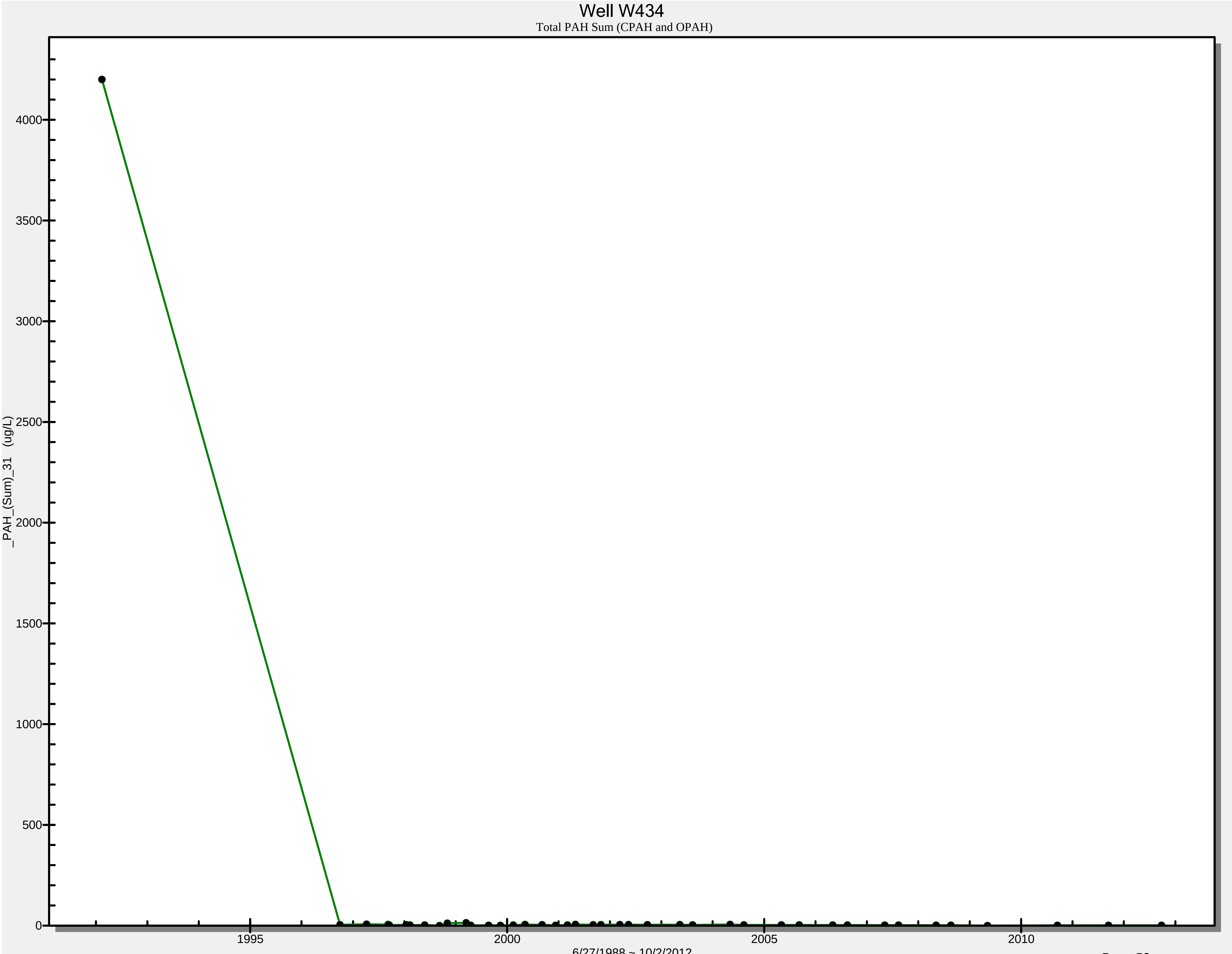


Well W431
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

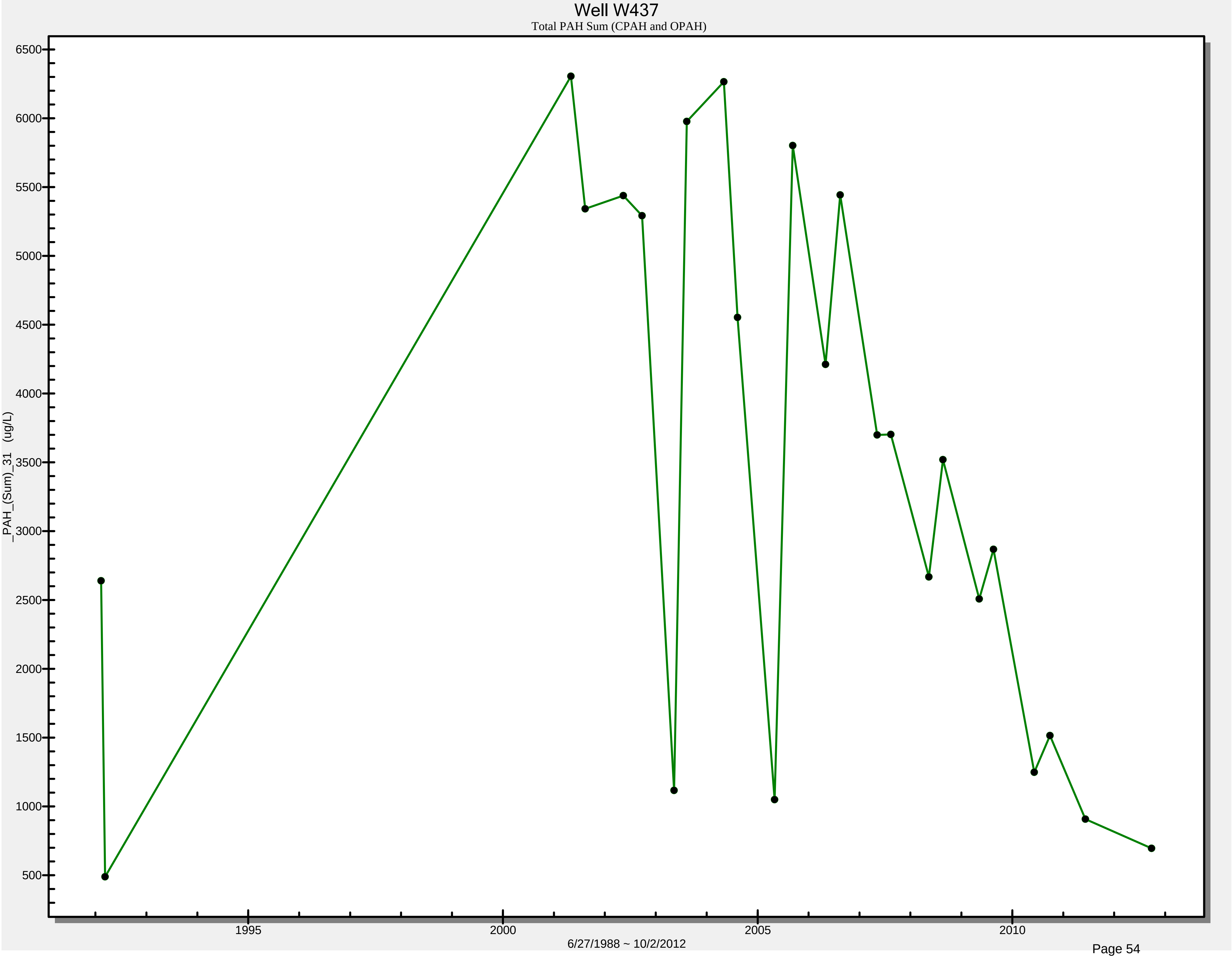


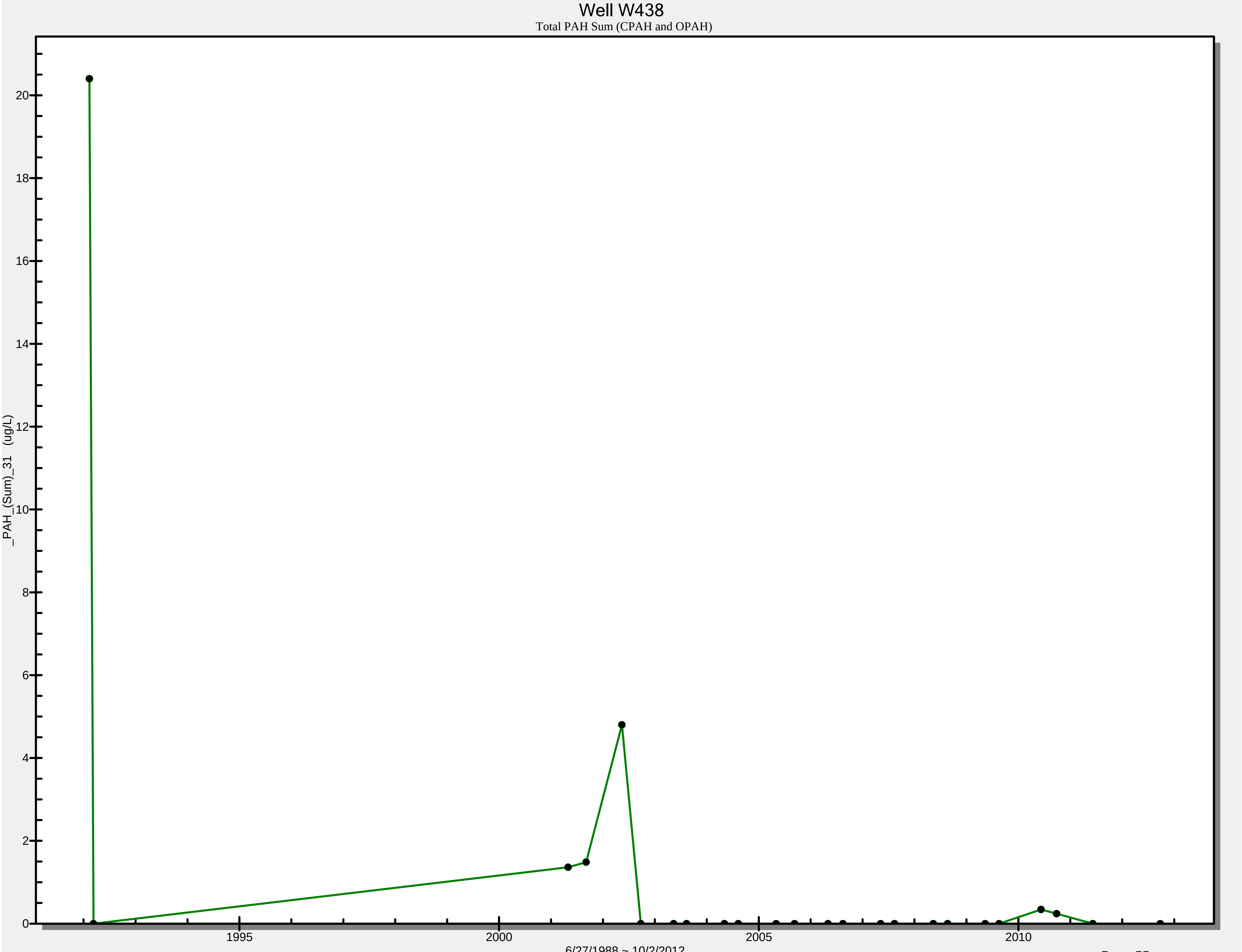
Well W432
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
5
10
15
20
25
30
1995
2000
6/27/1988 ~ 10/2/2012

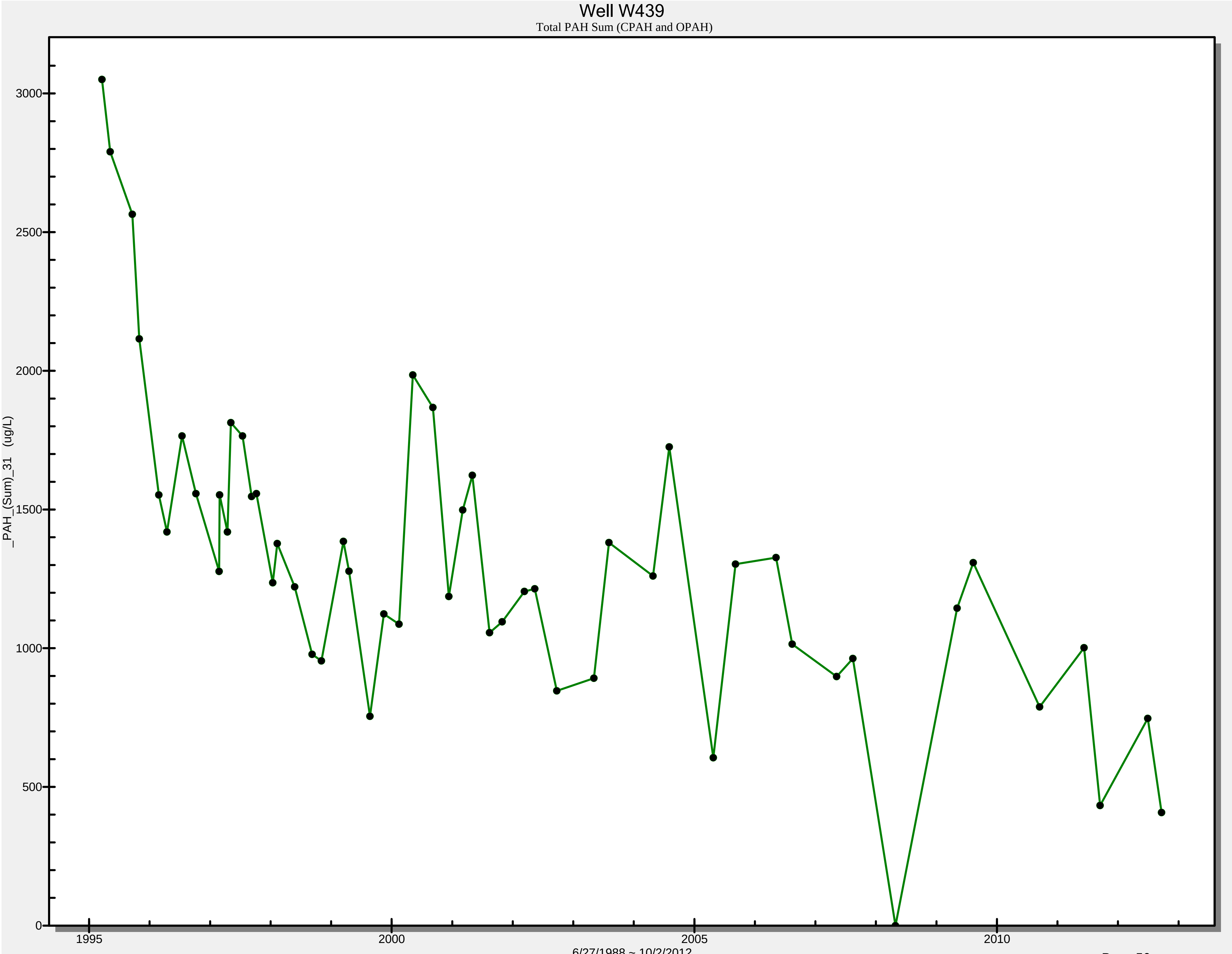

Well W433
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2000
2005
2010
6/27/1988 ~ 10/2/2012

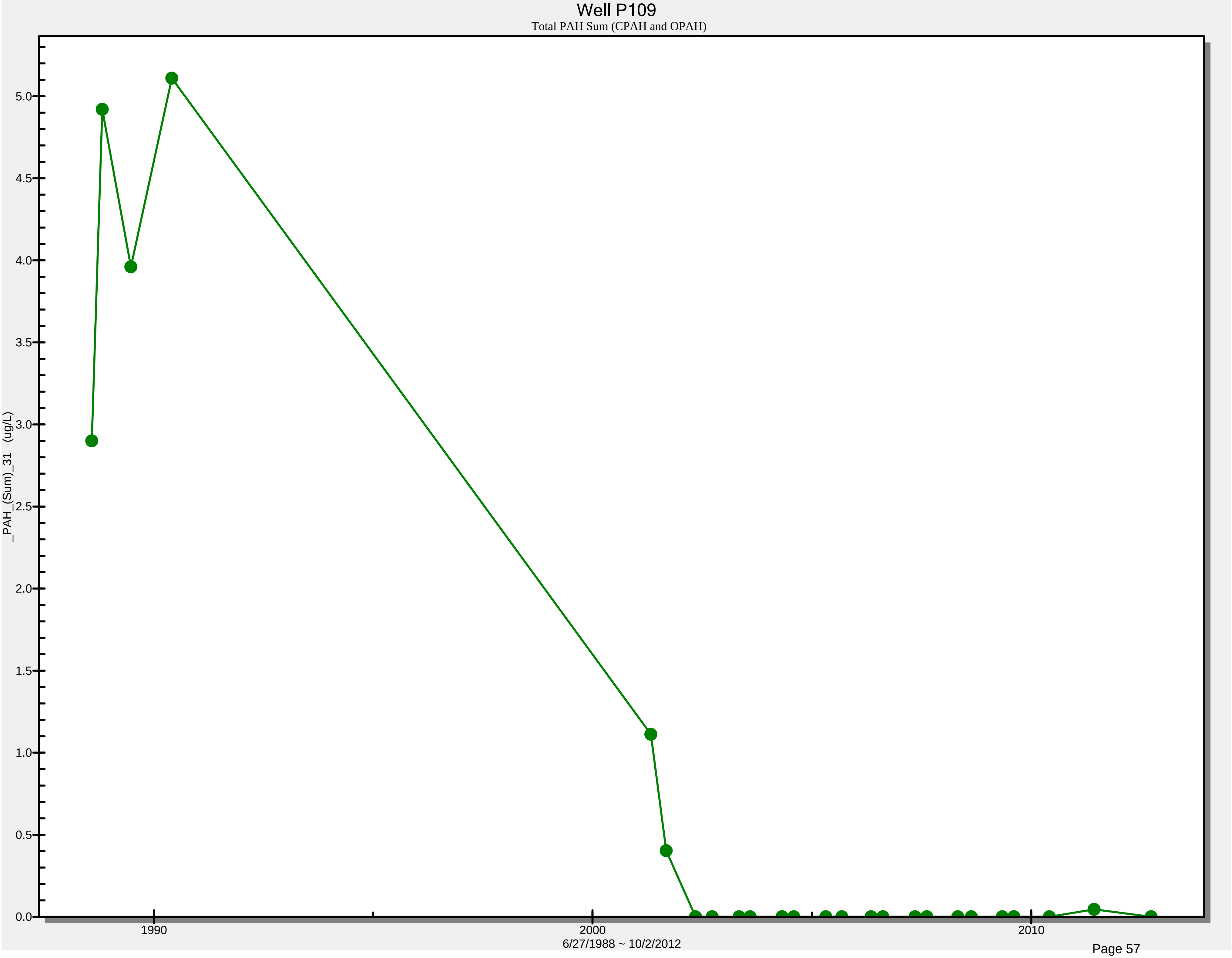


Well W434
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
4000
3500
3000
2500
2000
1500
1000
500
0
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

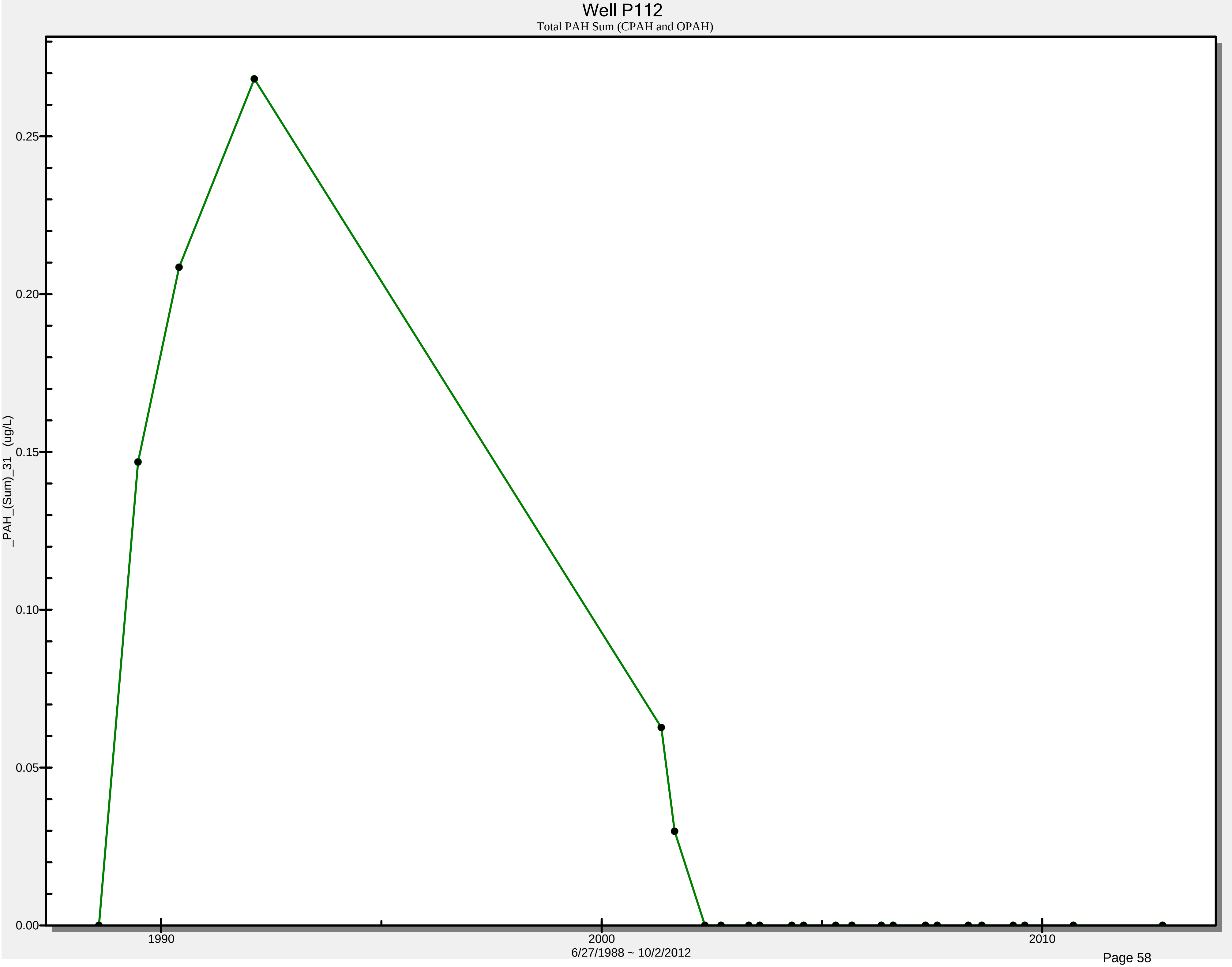

Well W437
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012


Well W438
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
2
4
6
8
10
12
14
16
18
20
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

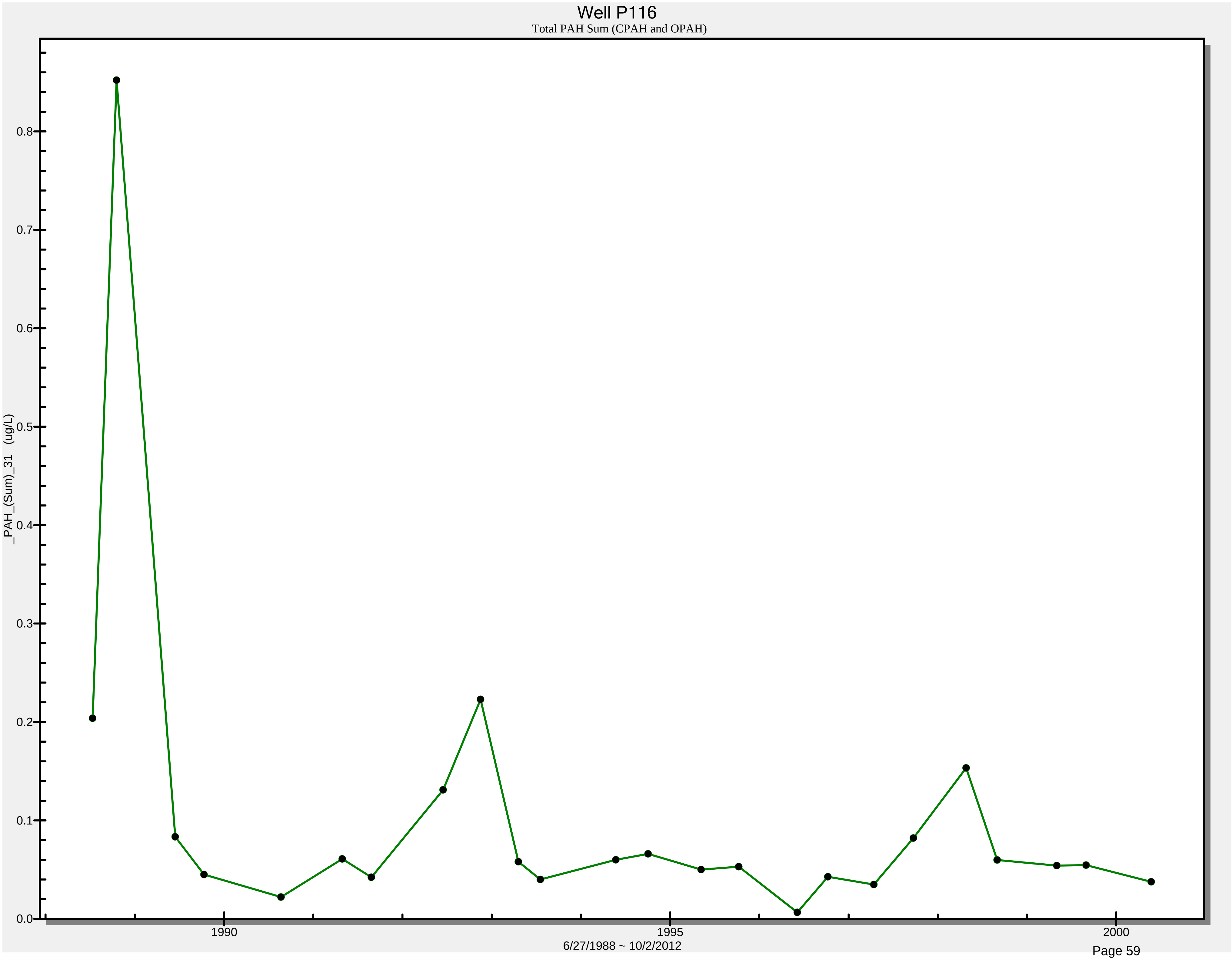

Well W439
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
3000
2500
2000
1500
1000
500
0
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

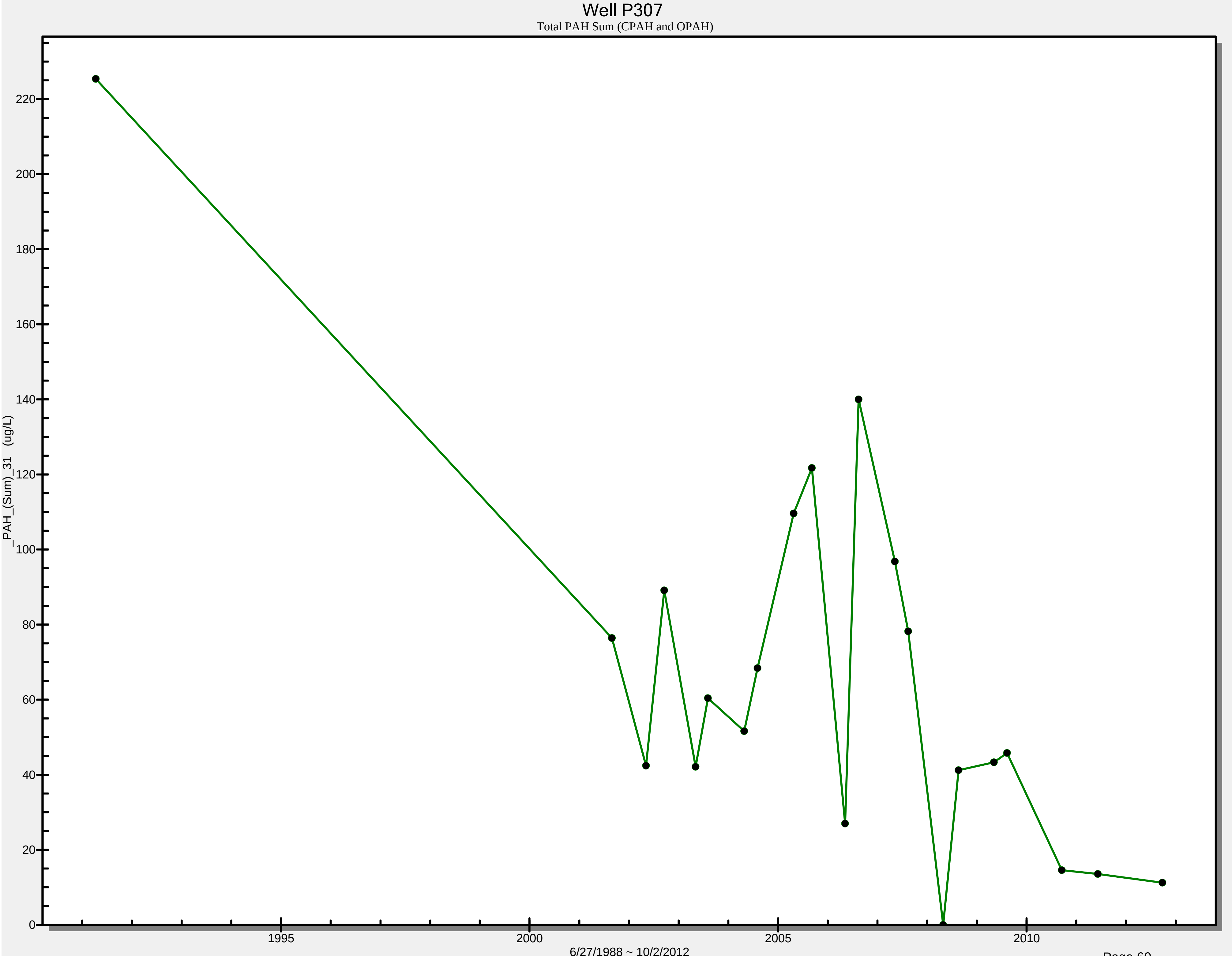


Well P109
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1990
2000
2010
6/27/1988 ~ 10/2/2012



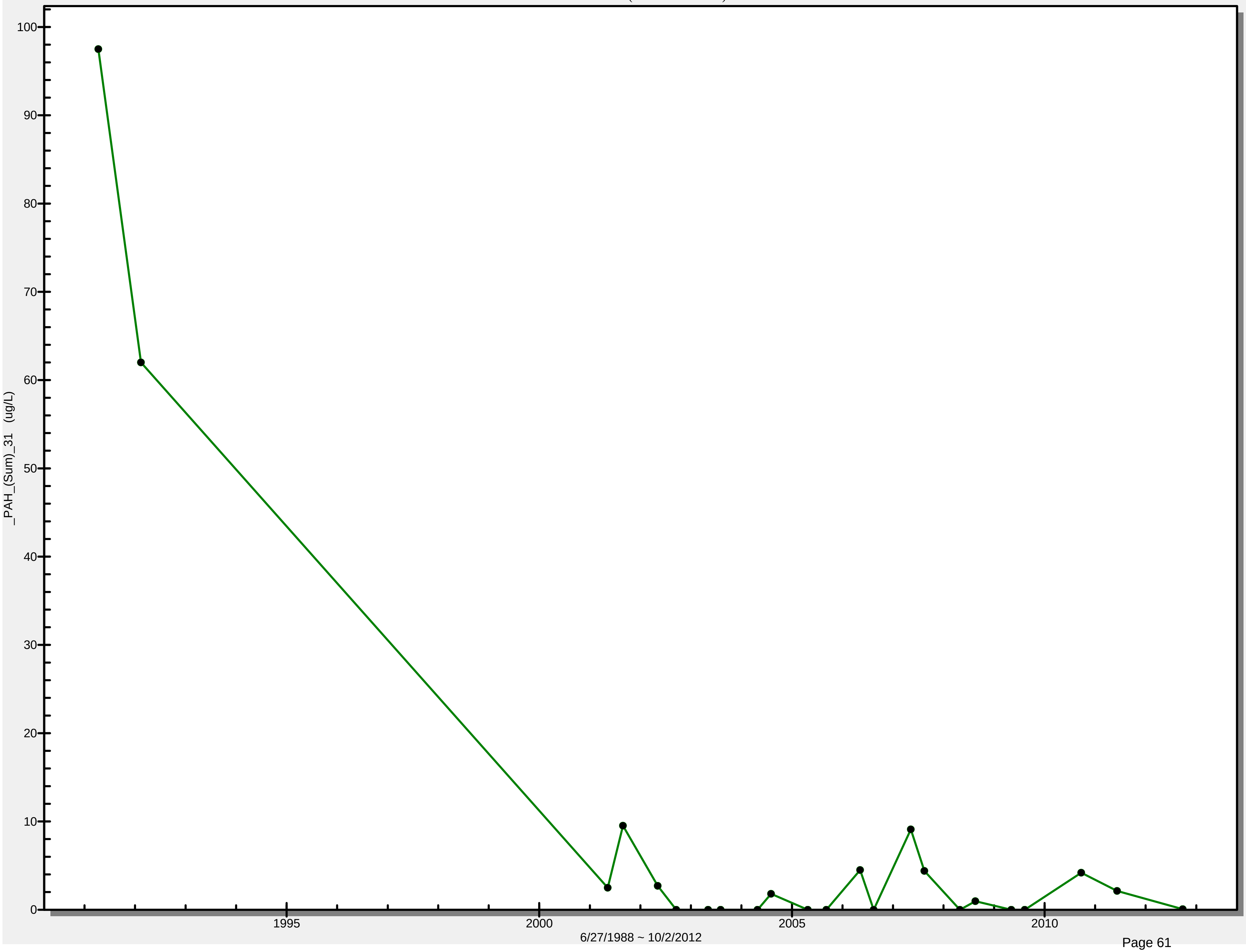
Well P112
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31_ (ug/L)
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well P116
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1990
1995
2000
6/27/1988 ~ 10/2/2012


Well P307
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
20
40
60
80
100
120
140
160
180
200
220
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

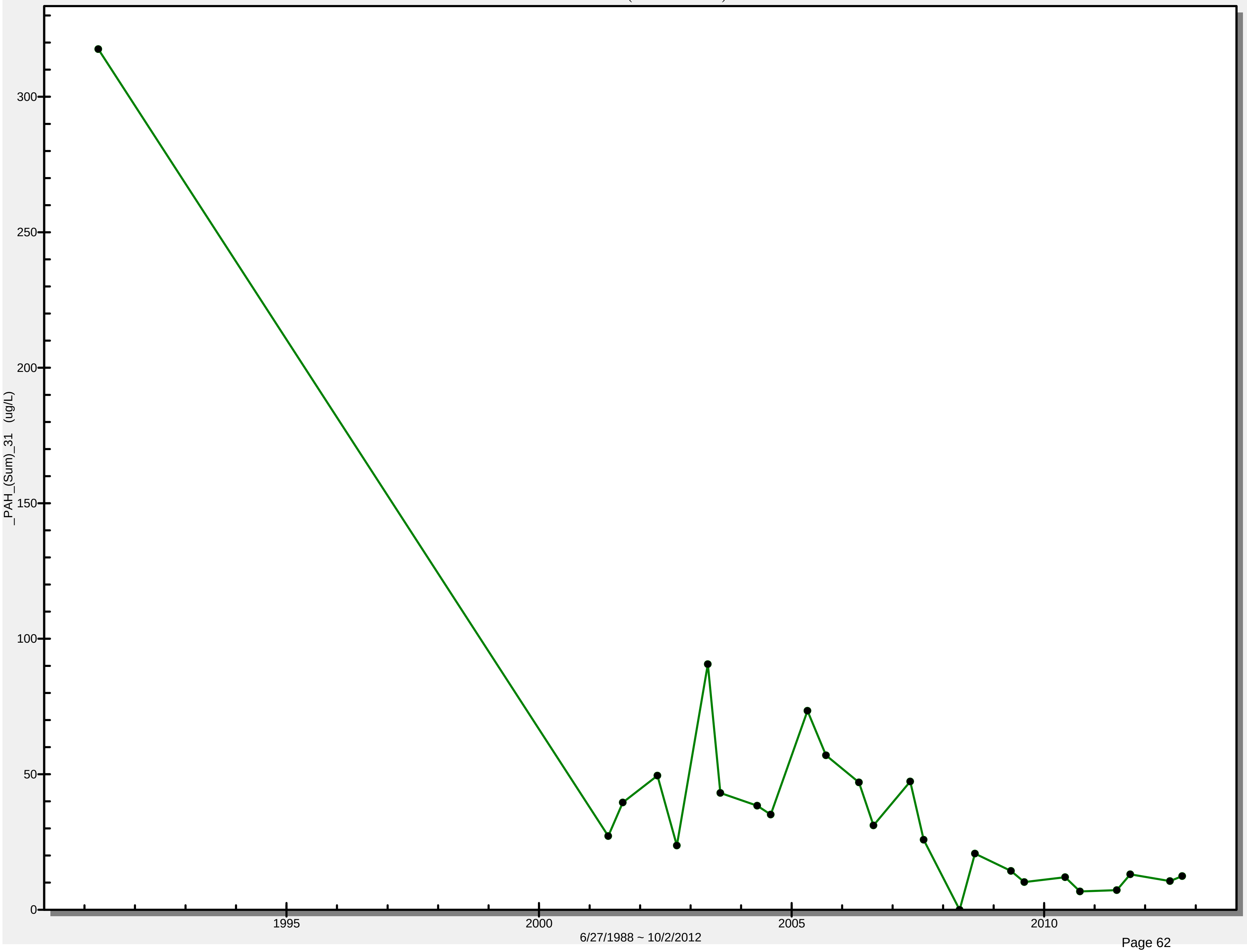
Well P308

Total PAH Sum (CPAH and OPAH)



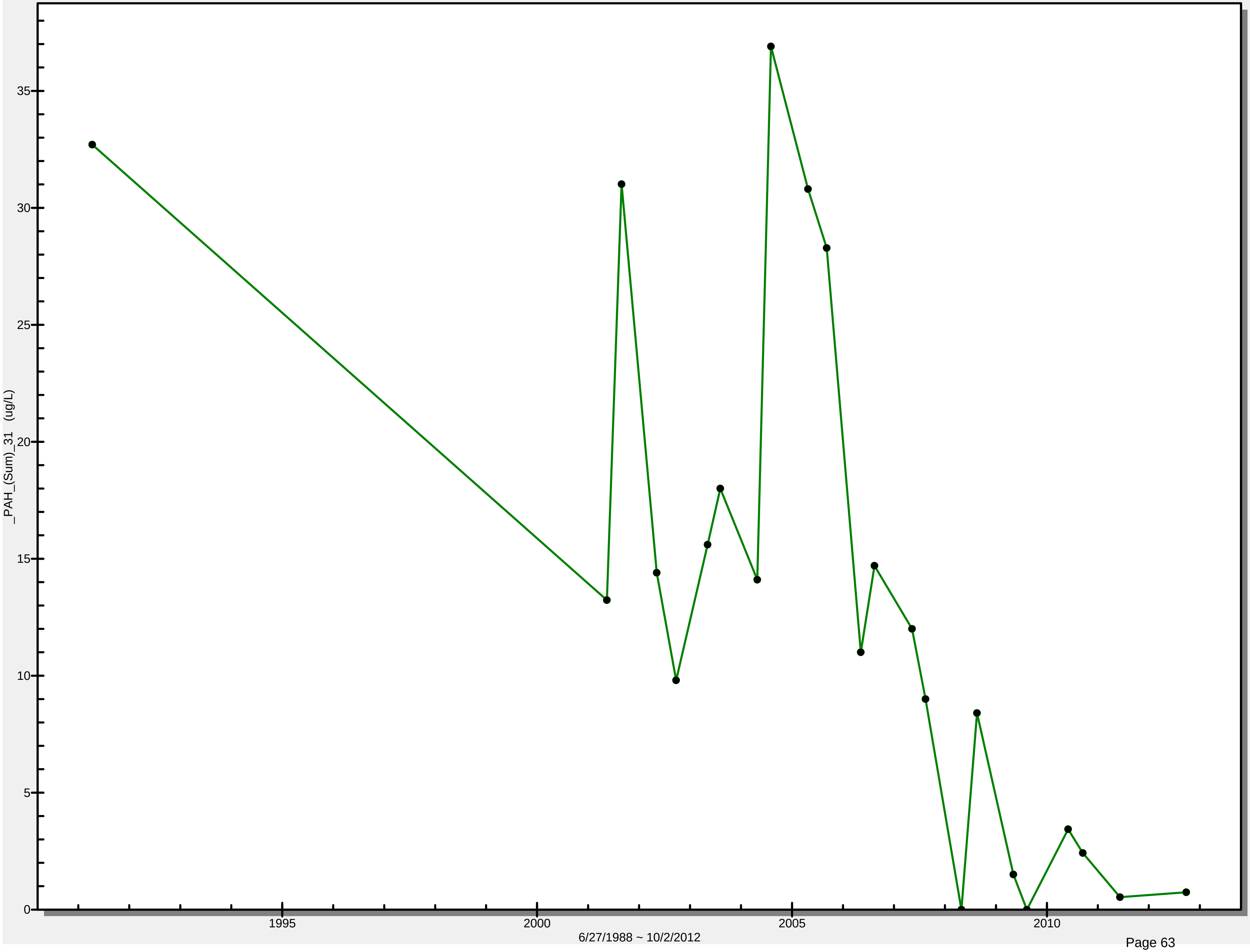
Well P309

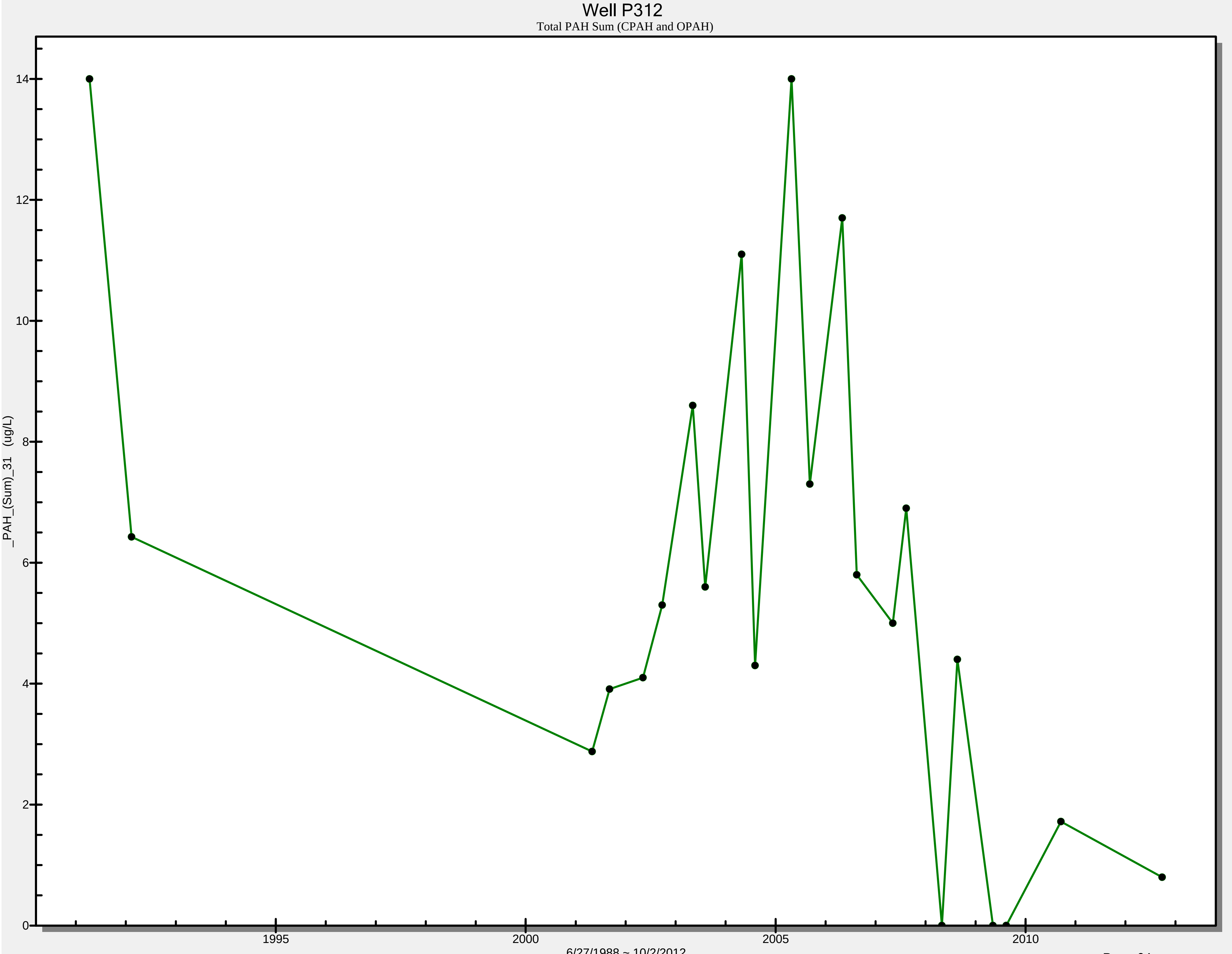
Total PAH Sum (CPAH and OPAH)

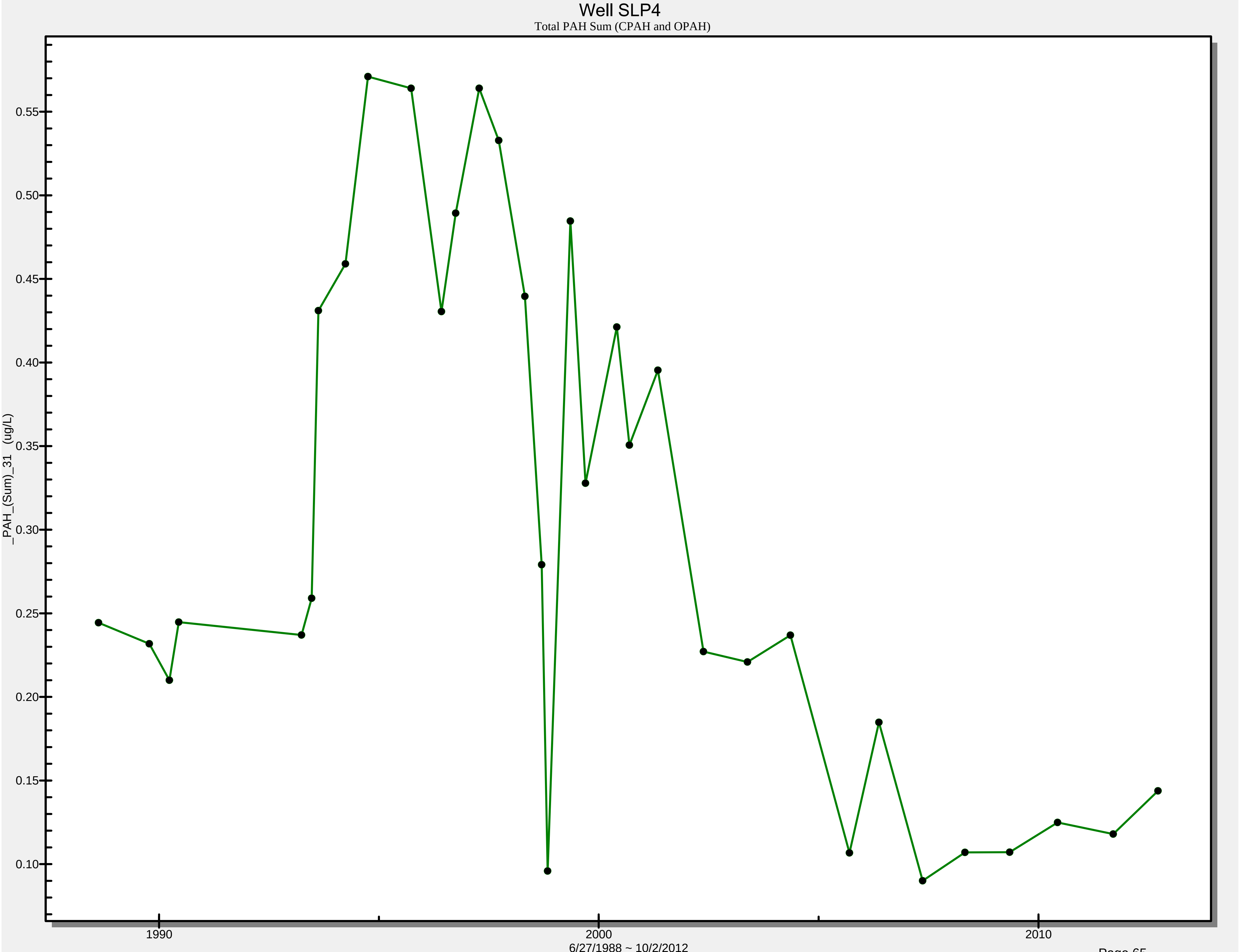


Well P310

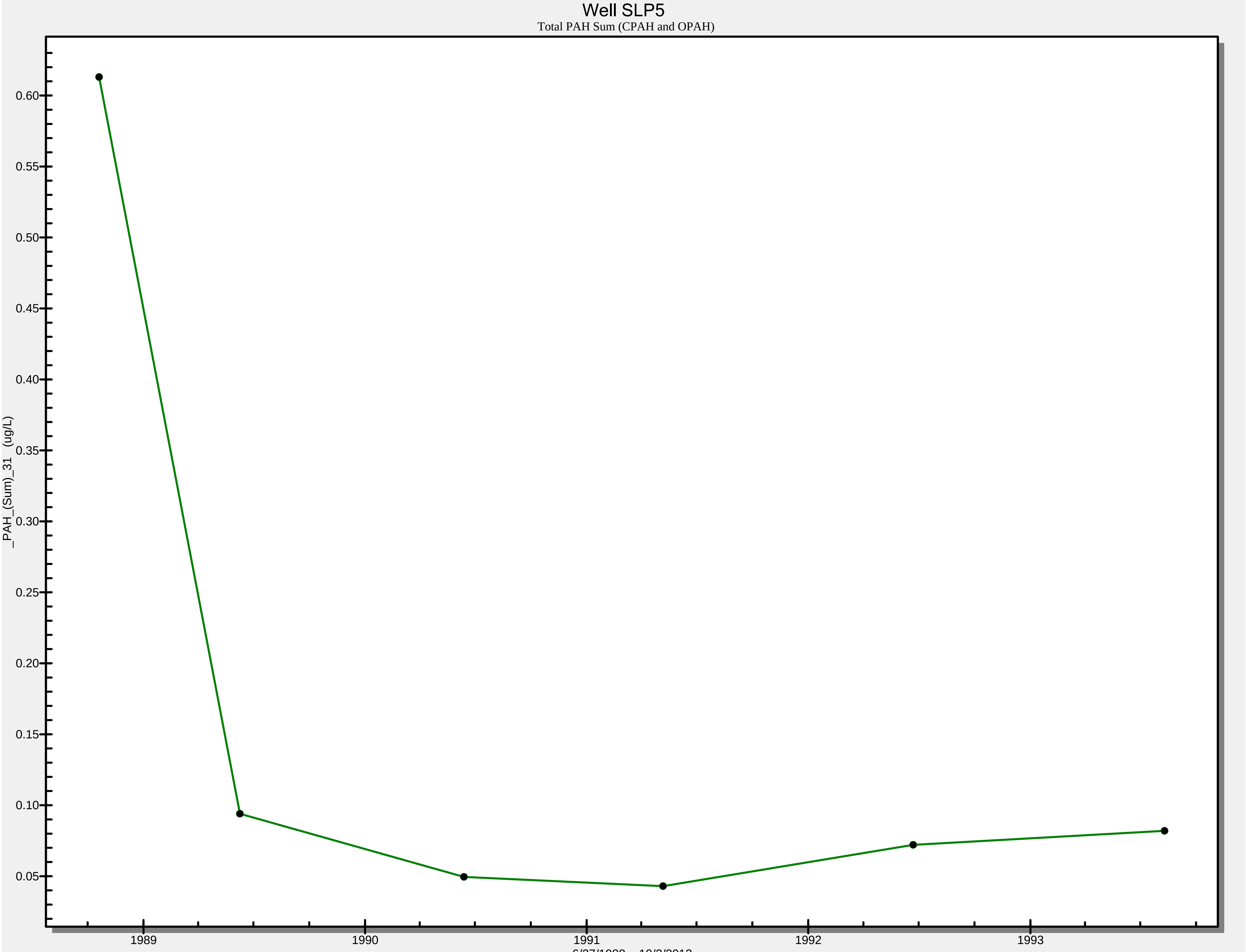
Total PAH Sum (CPAH and OPAH)



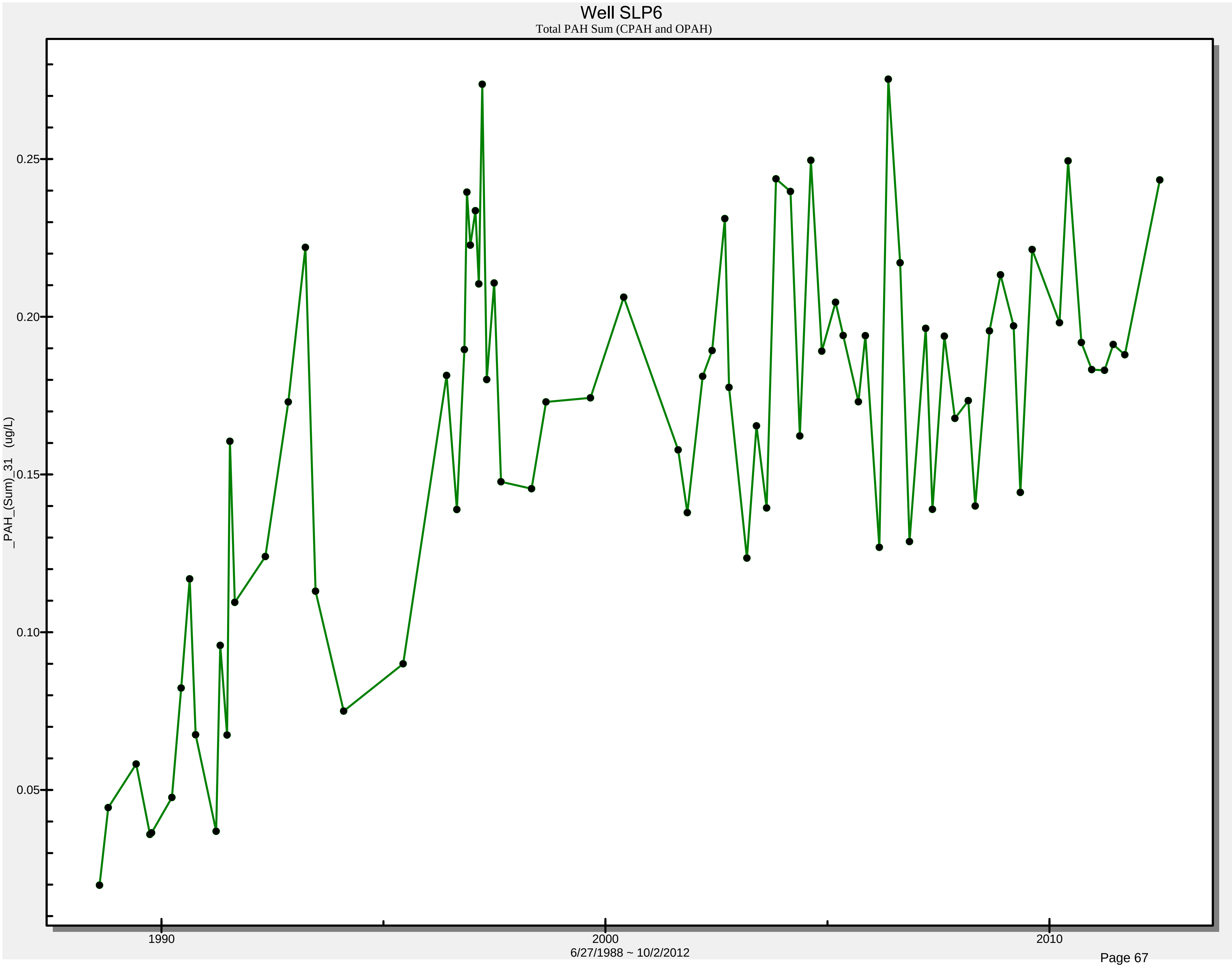

Well P312
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
2
4
6
8
10
12
14
1995
2000
2005
2010
6/27/1988 ~ 10/2/2012

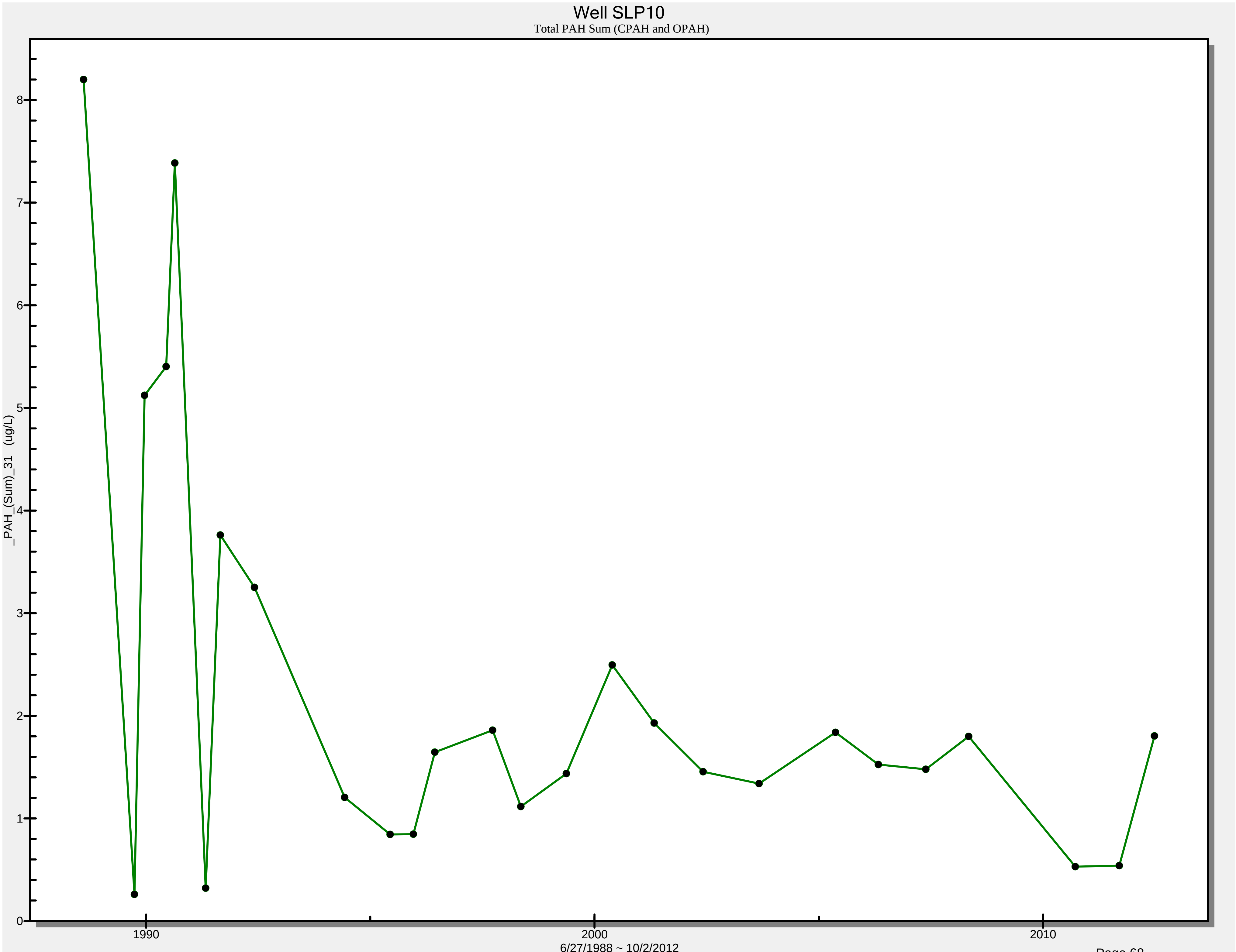


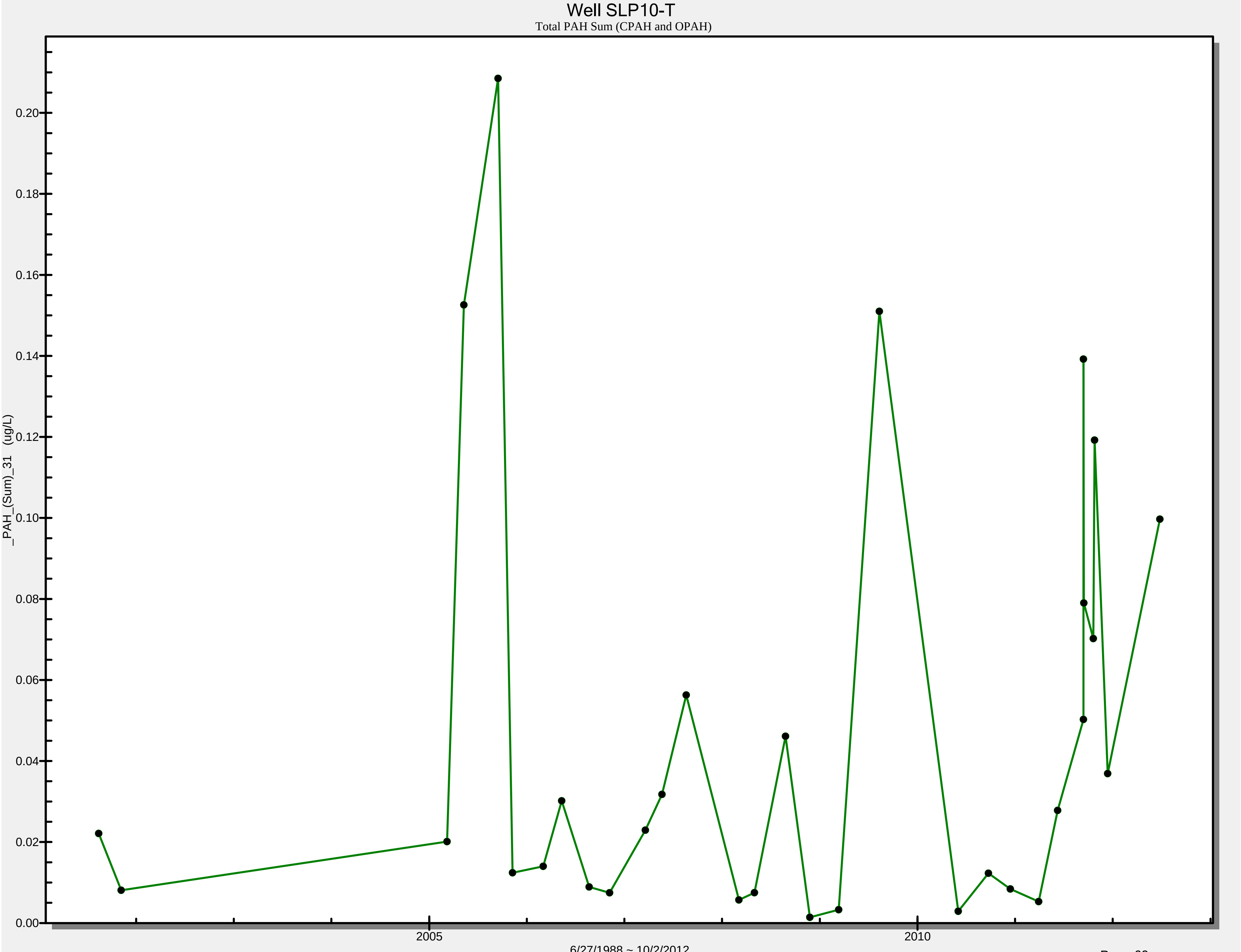
Well SLP4
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
1990
2000
2010
6/27/1988 ~ 10/2/2012

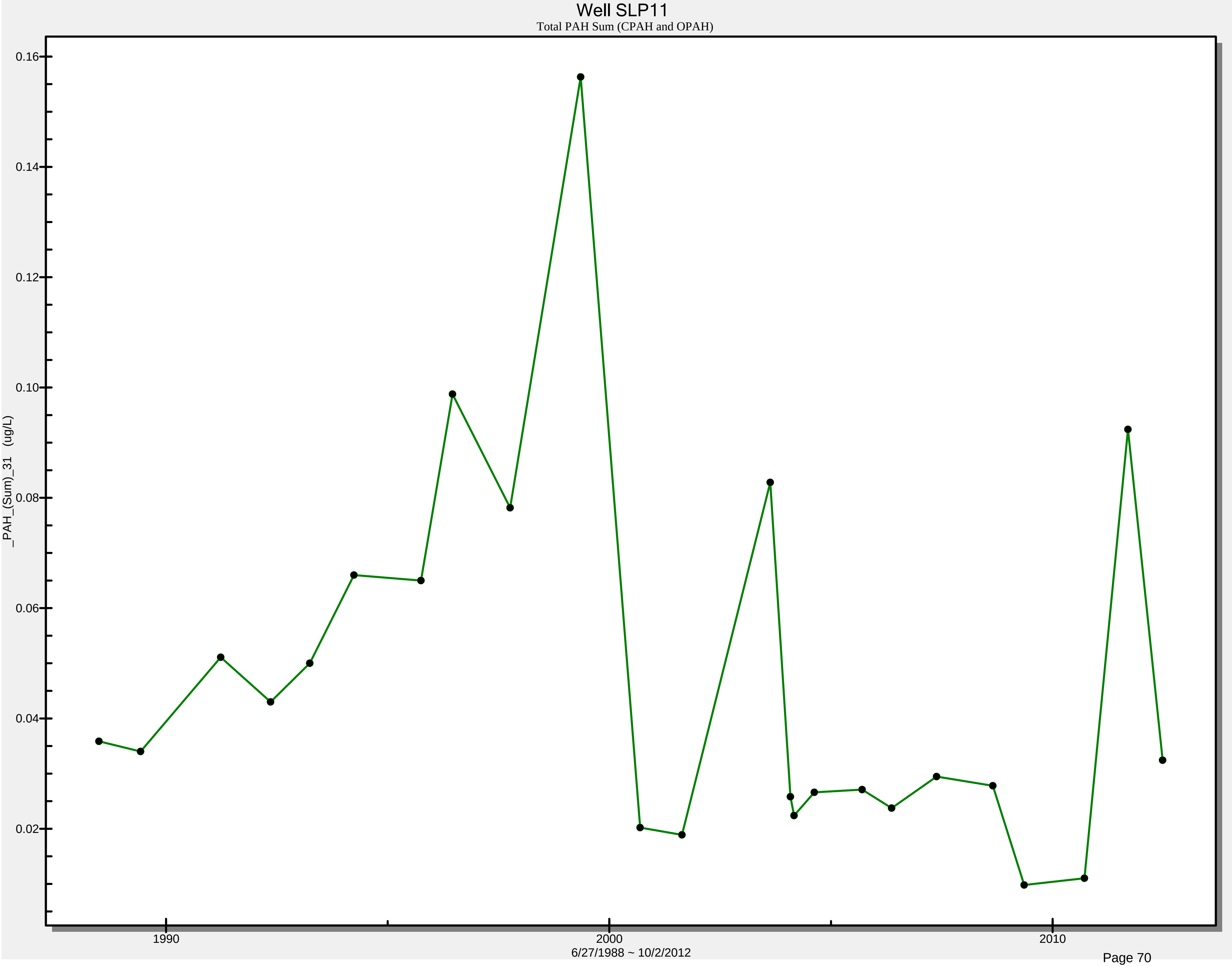


Well SLP5
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31_ (ug/L)
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
1989
1990
1991
1992
1993
6/27/1988 ~ 10/2/2012

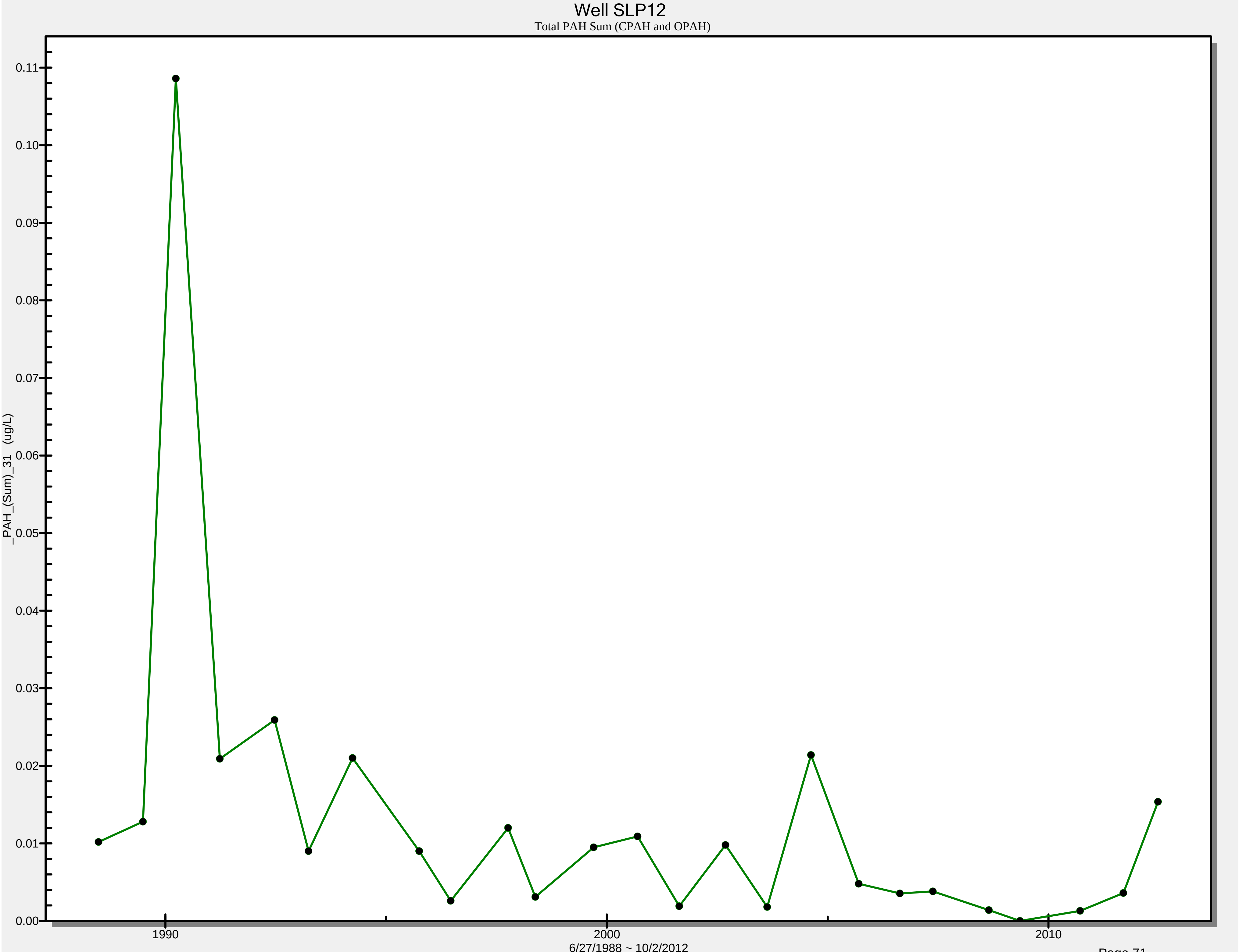

Well SLP6
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.25
0.20
0.15
0.10
0.05
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well SLP10
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0
1
2
3
4
5
6
7
8
1990
2000
2010
6/27/1988 ~ 10/2/2012

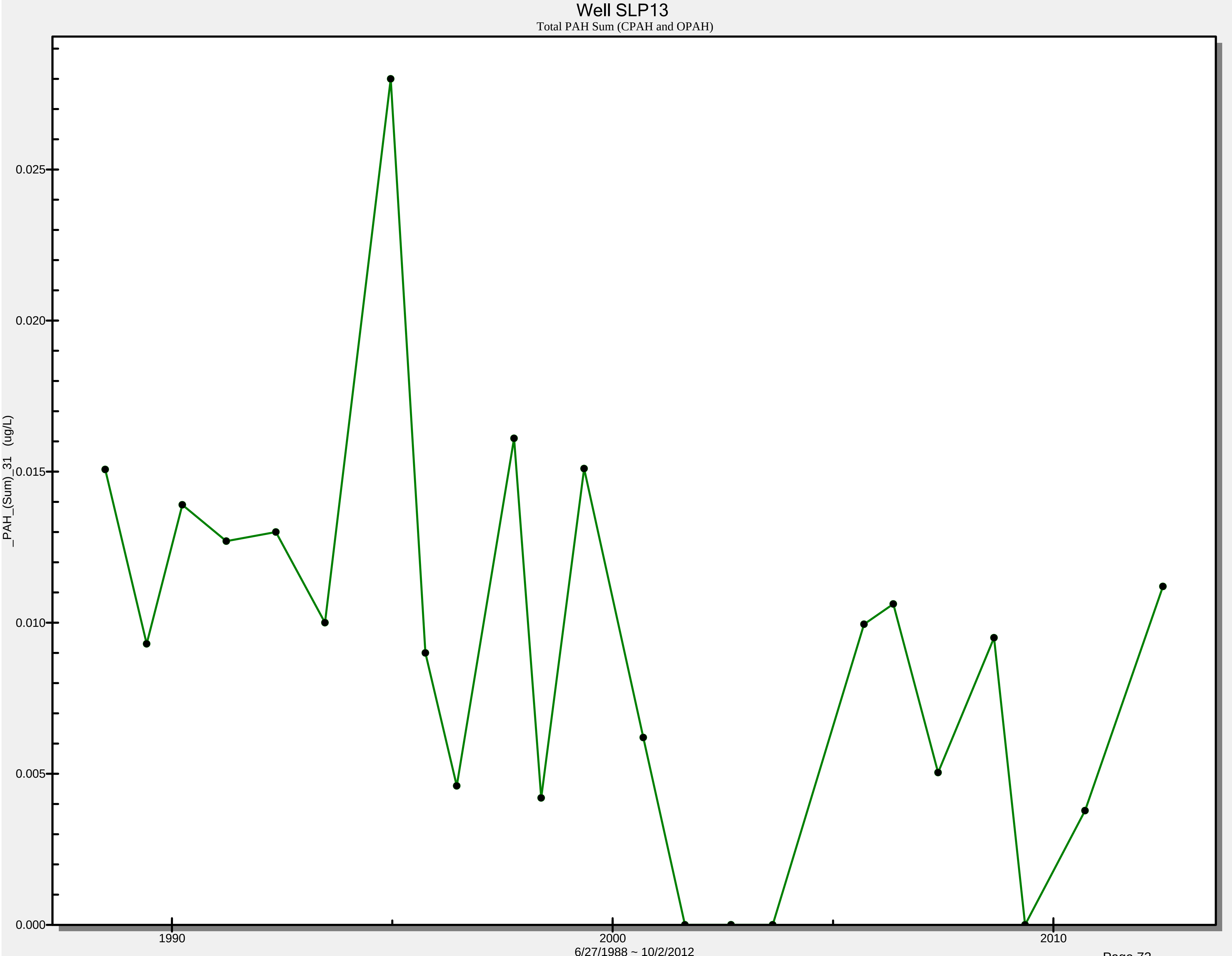

Well SLP10-T
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2005
2010
6/27/1988 ~ 10/2/2012



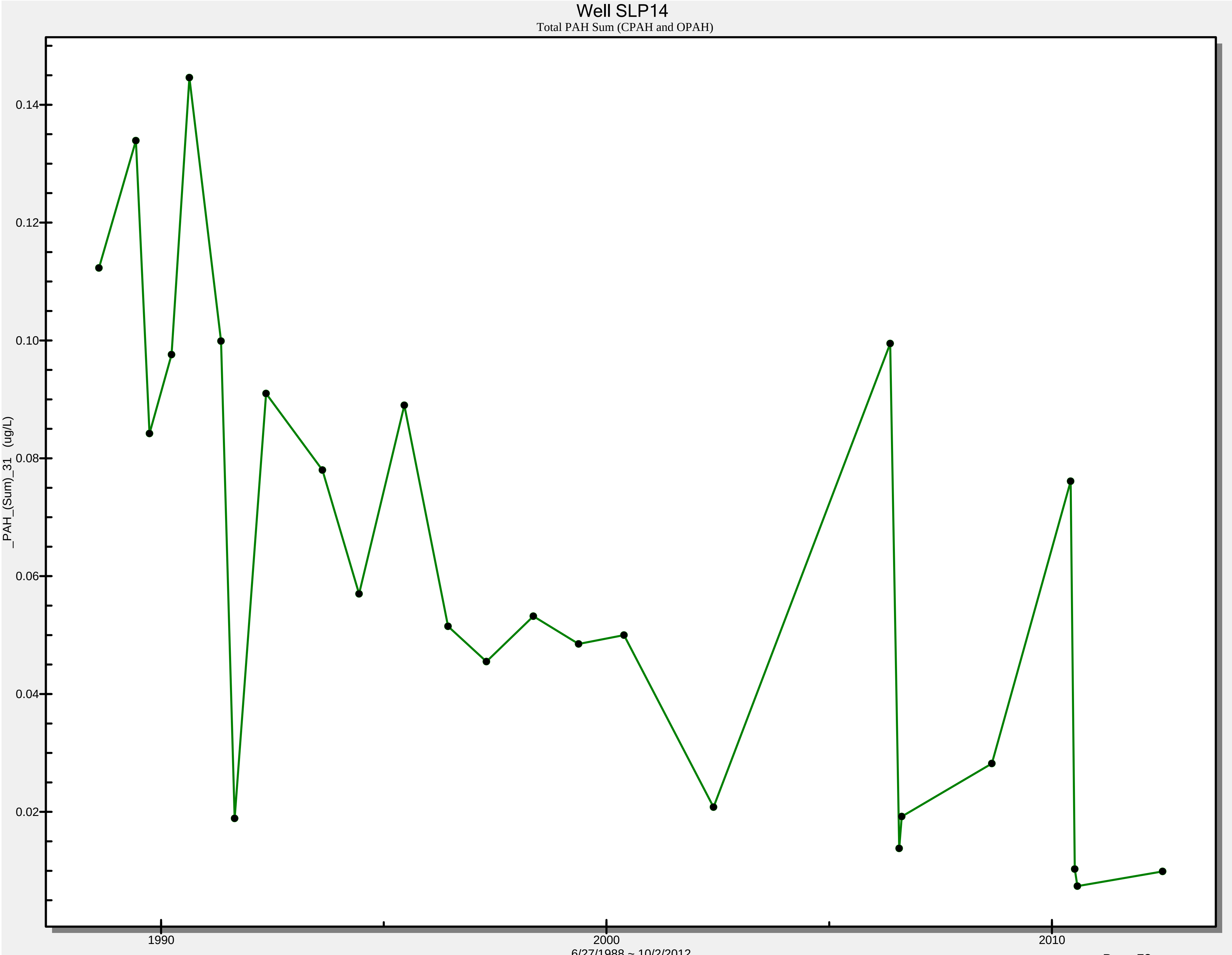
Well SLP11
Total PAH Sum (CPAH and OPAH)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
PAH(Sum)_31 (ug/L)
1990
2000
2010
6/27/1988 ~ 10/2/2012



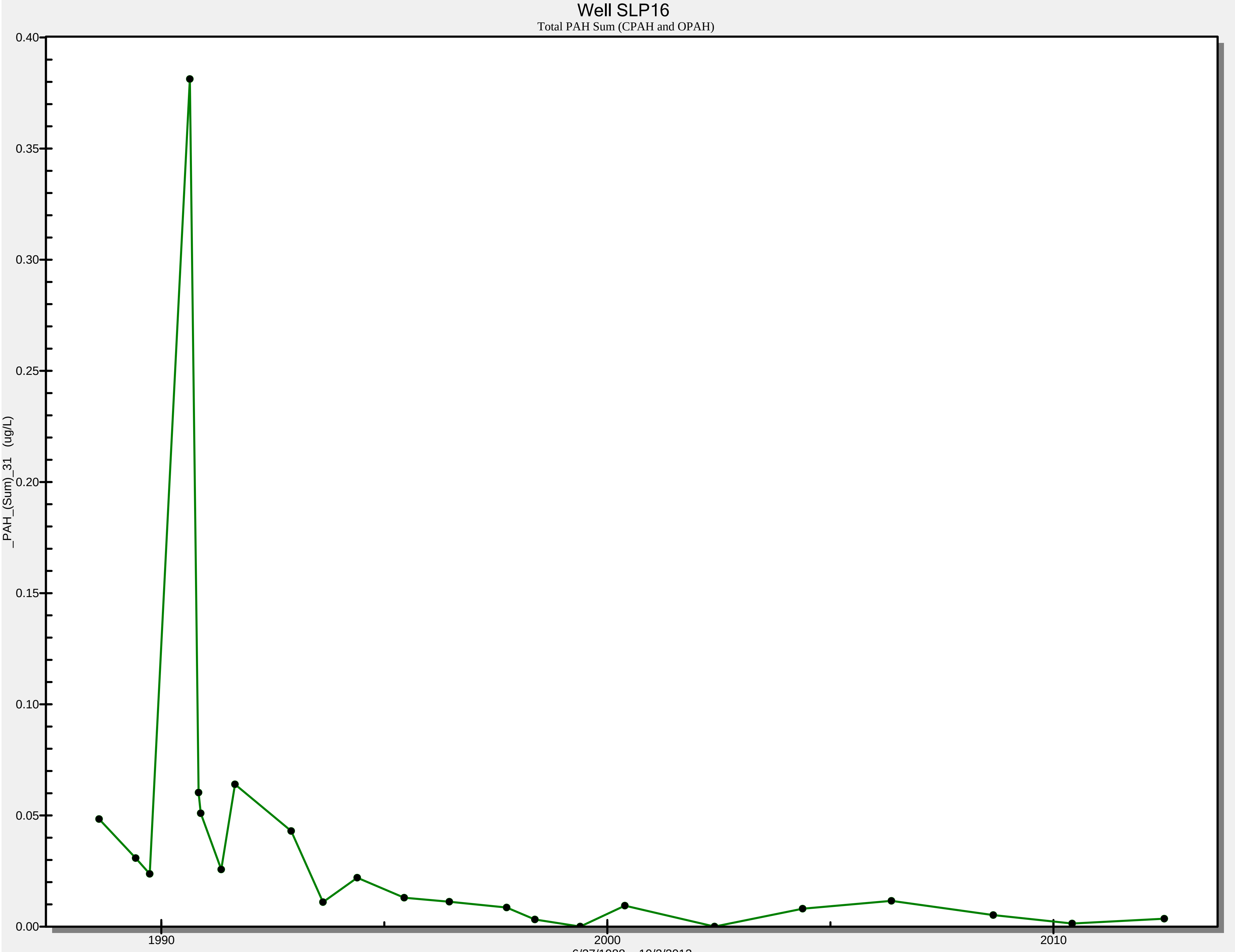
Well SLP12
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012



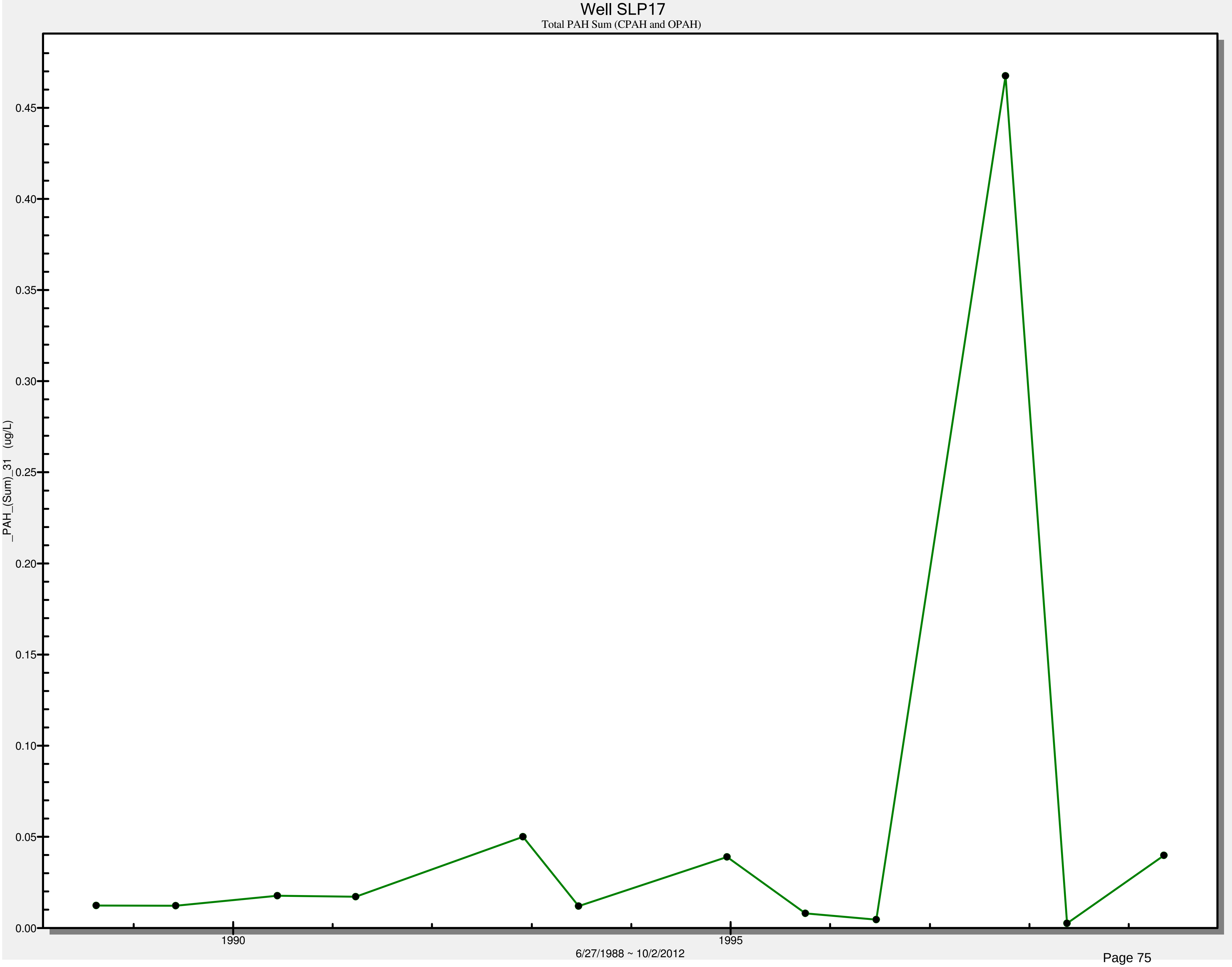
Well SLP13
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.025
0.020
0.015
0.010
0.005
0.000
1990
2000
2010
6/27/1988 ~ 10/2/2012



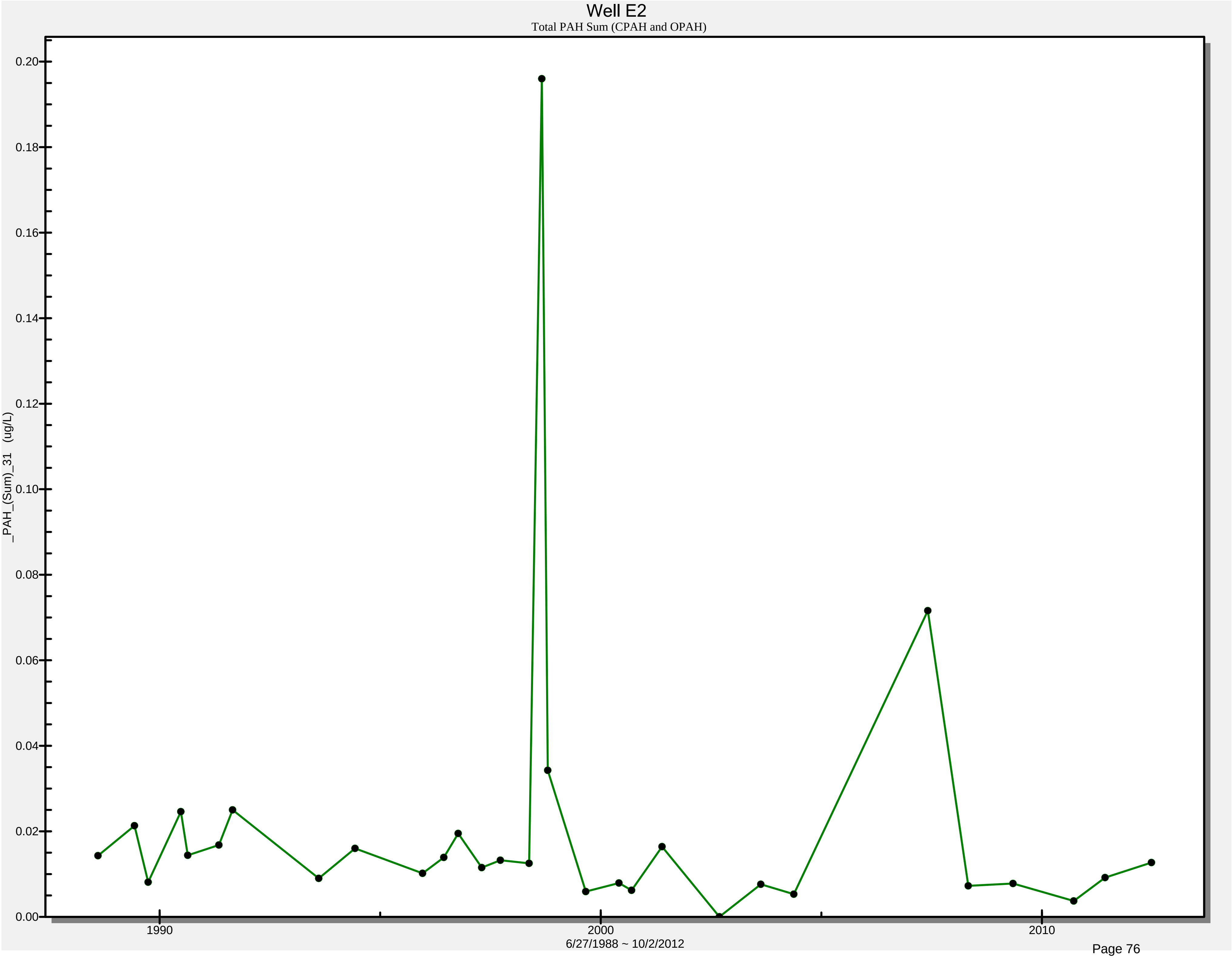
Well SLP14
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
1990
2000
2010
6/27/1988 ~ 10/2/2012



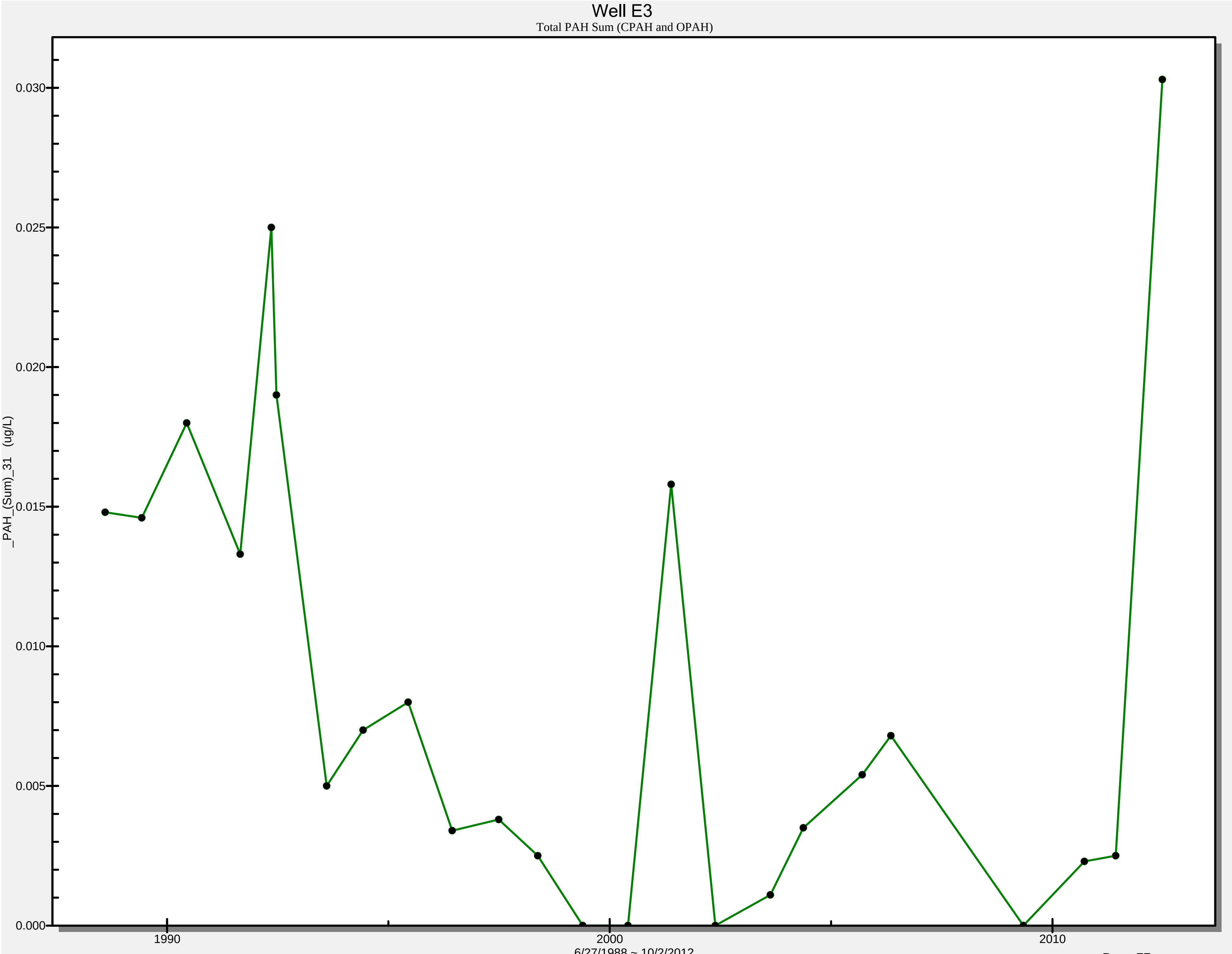
Well SLP16
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012



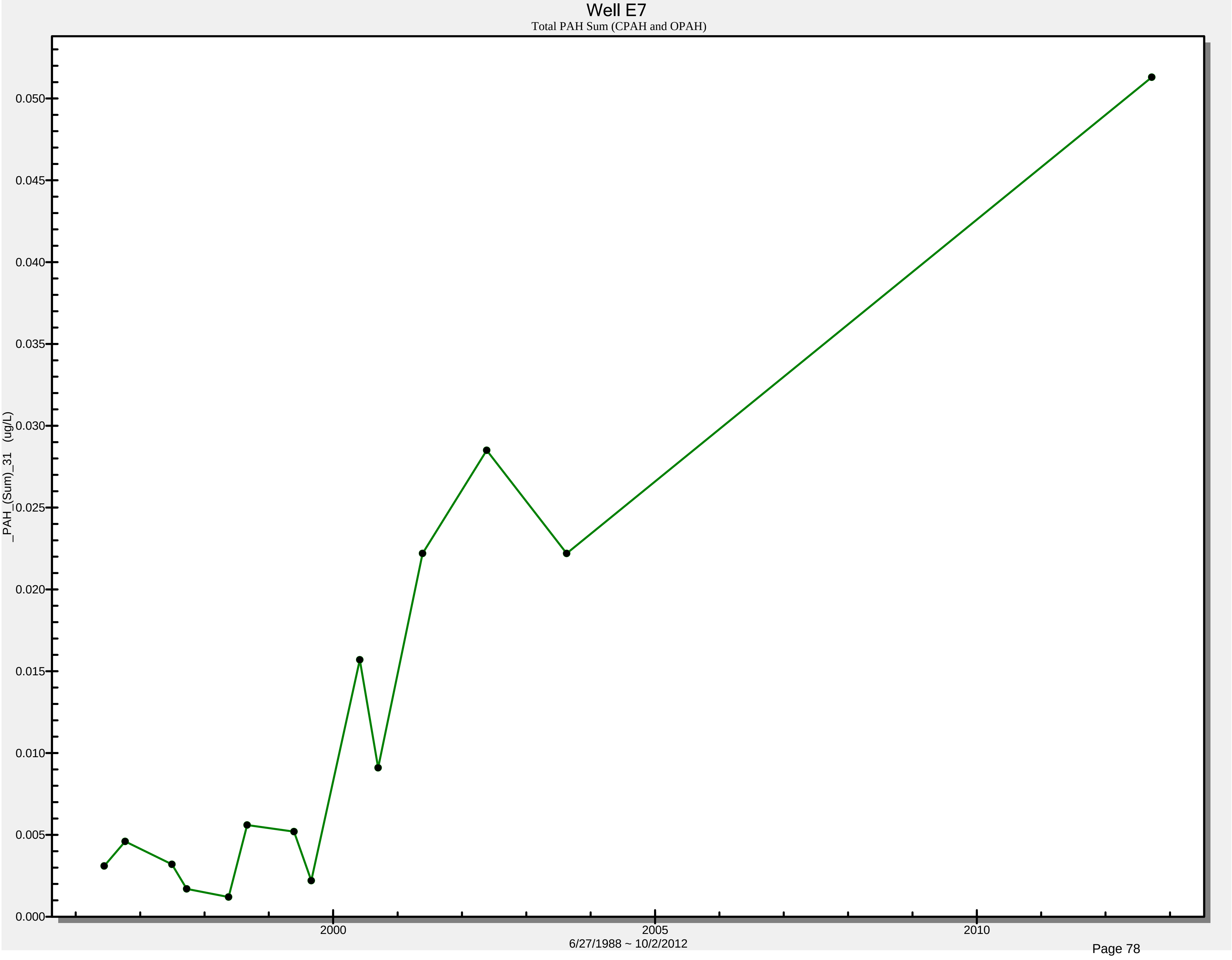
Well SLP17
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
1995
6/27/1988 ~ 10/2/2012



Well E2
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012



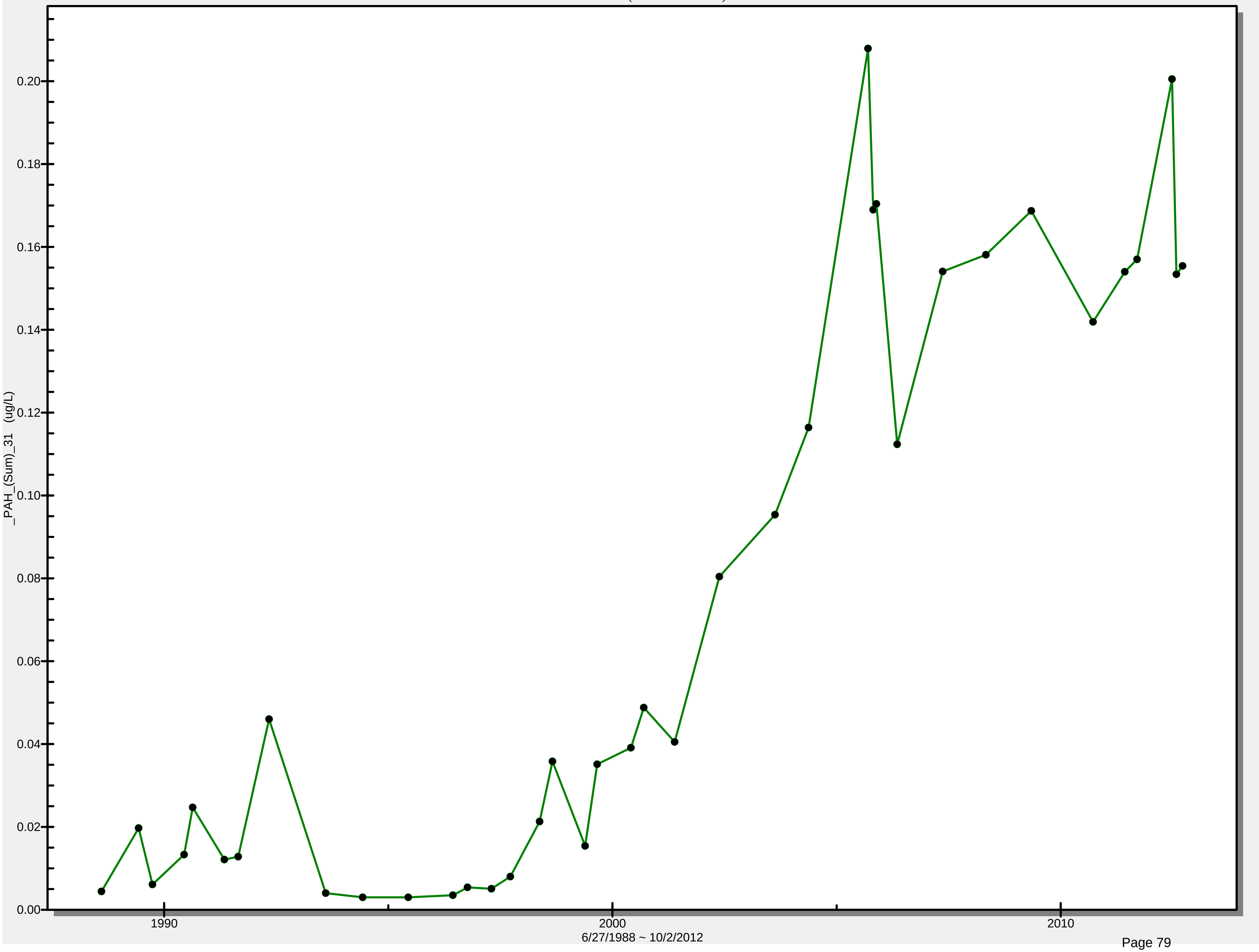
Well E3
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1990
2000
2010
6/27/1988 ~ 10/2/2012

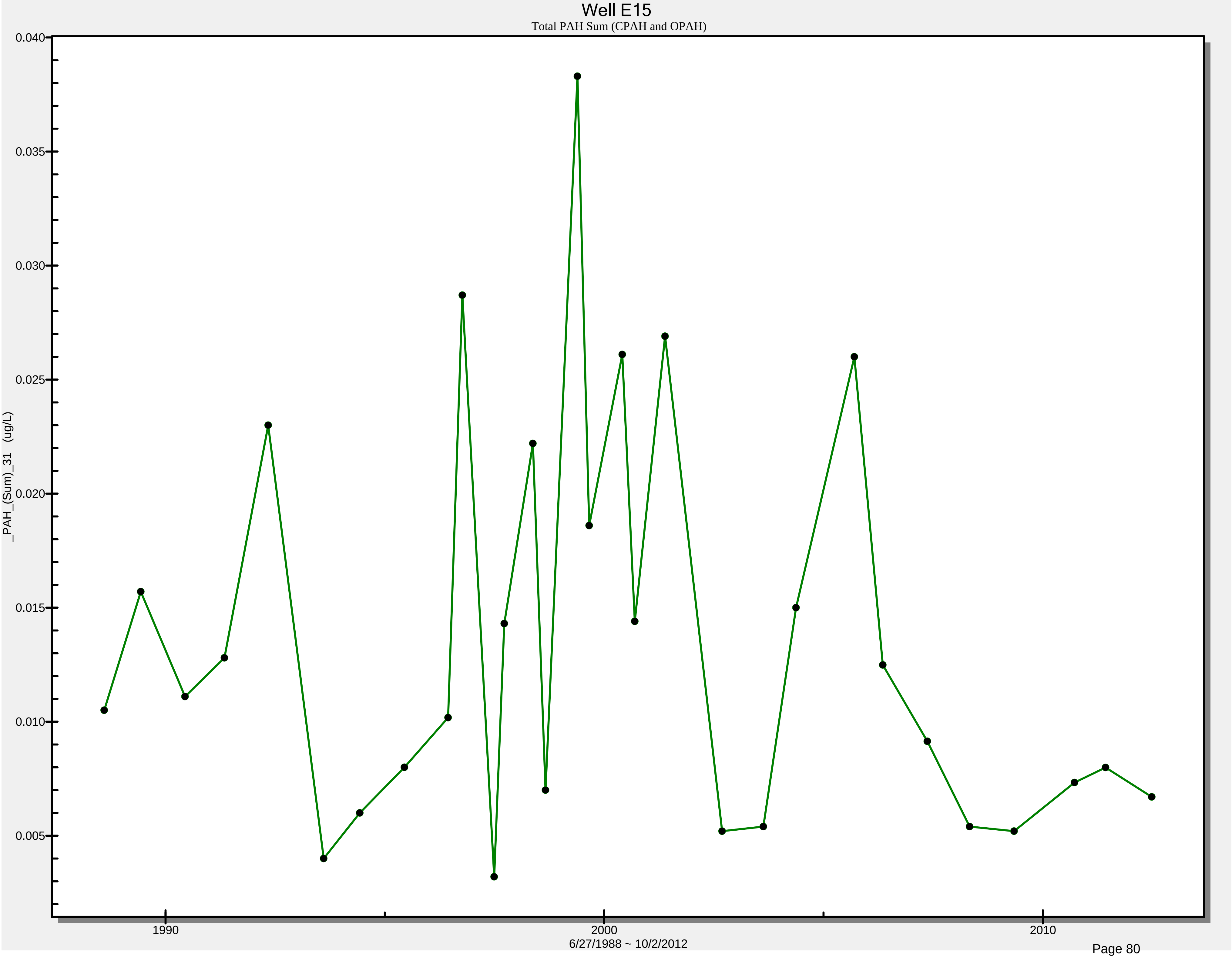


Well E7
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
2000
2005
2010
6/27/1988 ~ 10/2/2012

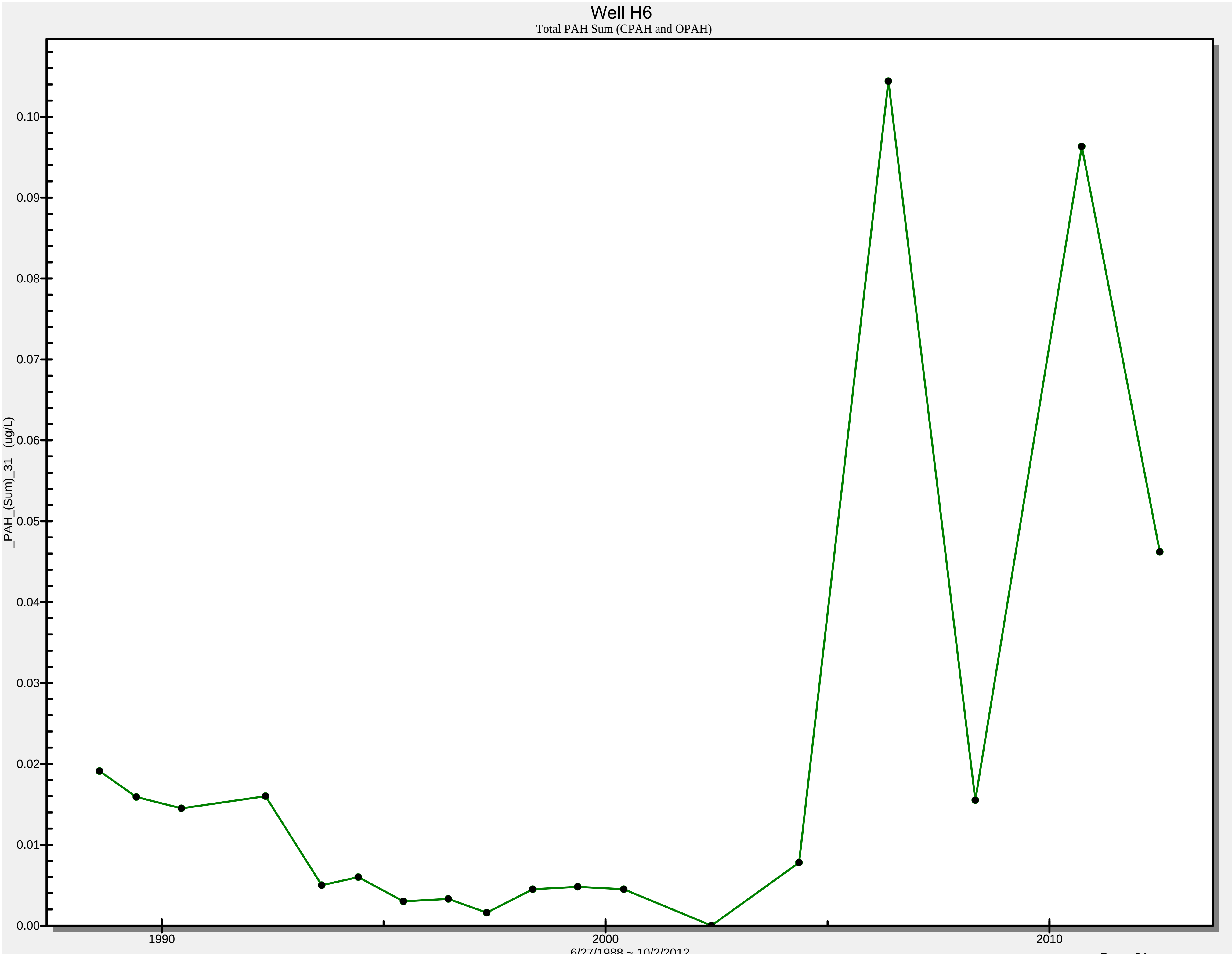
Well E13

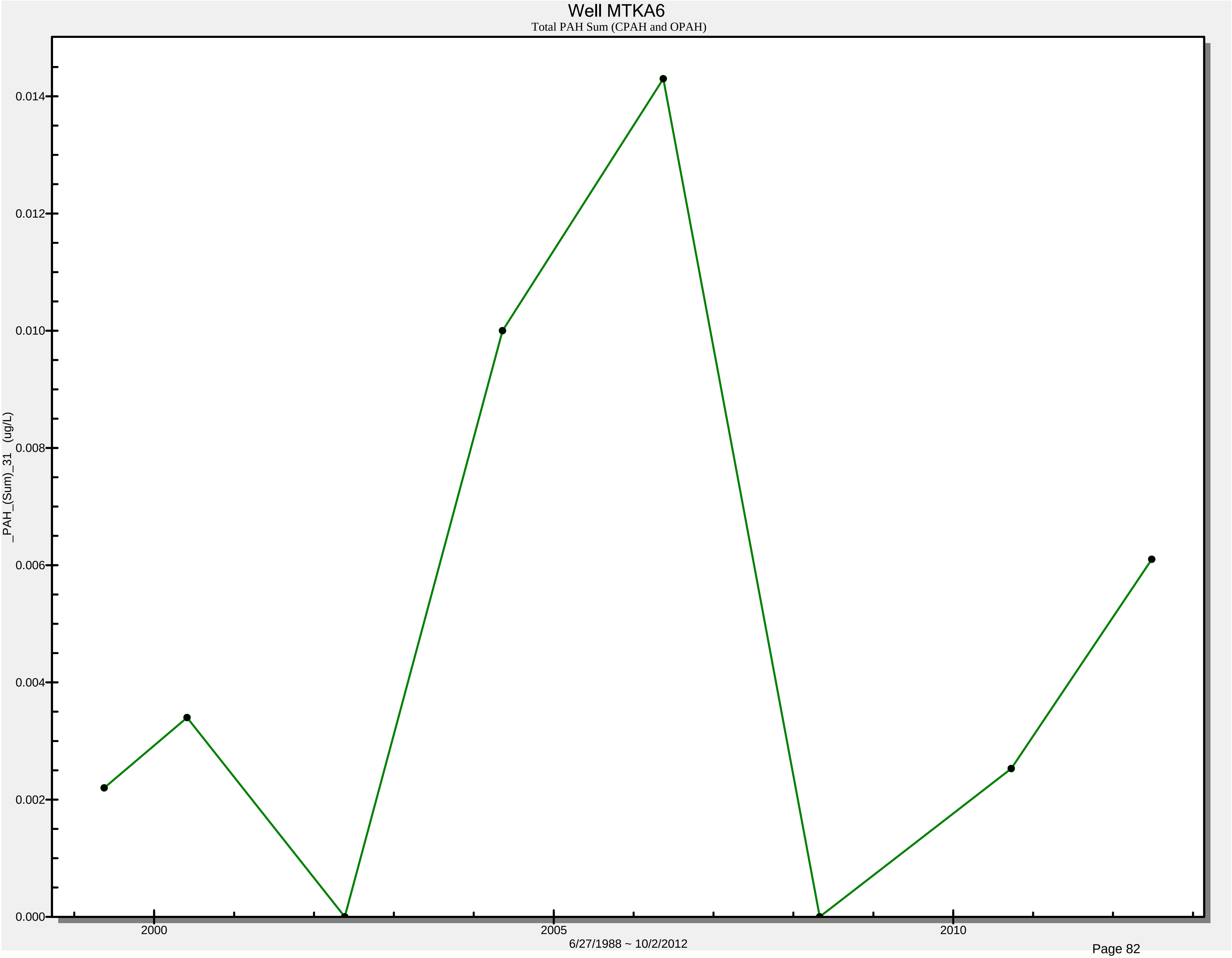
Total PAH Sum (CPAH and OPAH)





Well E15
Total PAH Sum (CPAH and OPAH)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
PAH(Sum)_31 (ug/L)
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well H6
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31 (ug/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1990
2000
2010
6/27/1988 ~ 10/2/2012


Well MTKA6
Total PAH Sum (CPAH and OPAH)
PAH(Sum)_31_ (ug/L)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
2000
2005
2010
6/27/1988 ~ 10/2/2012

Appendix B

Agency Correspondence Regarding Cessation

Minnesota Pollution Control Agency

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

December 6, 1999

Mr. Charles Meyer, City Manager
City of St. Louis Park
5065 Minnetonka Boulevard
St. Louis Park, MN 55416

Mr. Thomas Reilly, Jr., President
Reilly Industries
300 North Meridian Street, Suite 1500
Indianapolis, IN 46204-1763

RE: United States of America, et al. VS. Reilly Tar & Chemical Corporation, et al.
File No. Civ. 4-89-468, Consent Decree - Remedial Action Plan (CD-RAP)
Section 9.2; Drift-Platteville Aquifer Gradient Control Cessation Criteria

Dear Mr. Meyer and Mr. Reilly:

The Minnesota Pollution Control Agency (MPCA) and U.S. Environmental Protection Agency (U.S. EPA) are in receipt of the letter prepared by ENSR, dated September 28, 1999. The letter proposed cessation criteria for the Drift Aquifer gradient control well W422 and Platteville Aquifer gradient control well W434.

The MPCA and U.S. EPA are unable to approve the proposed cessation criteria based on the information provided. The cessation criteria need to be established to comply with the objective stated in the CD-RAP for the gradient control wells (Section 9.2.4). This objective is to "limit the spread of contamination into the area delineated by the buried bedrock valley", generally south of Highway 7, near Wooddale Avenue. Given this objective, it is necessary to consider the concentrations of contaminants and flow characteristics in the portion of the Drift-Platteville Aquifer that flows toward the bedrock valley, not at single compliance points. This approach is consistent with cessation requirements established in CD-RAP section 7.2.9 for Prairie du Chein well SLP4, where cessation of pumping is not allowed if contaminant concentrations exceed drinking water criteria within a specified geographic area.

Additionally, the CD-RAP (Section 9.2.4) requires gradient control wells to be operated at least five years. Well W422 meets this requirement; however, well W434 has been operating only since June 10, 1997.

Cessation Criteria

To evaluate cessation criteria and associated request to cease pumping, it is necessary to prepare a submittal incorporating the following components:

- Cessation Concentrations,
- Compliance with Gradient Control Objective;

- Assessment of Contaminant Spreading; and
- Criteria to Resume Gradient Control.

Cessation Concentrations - This component of the criteria is to propose the water quality concentrations to be used to determine when pumping can cease. The MPCA and U.S. EPA are in agreement that the concentrations established within the Minnesota Department of Health (MDH) Health Risk Limits (HRL) and related Health Based Values (HBV) are suitable for evaluating potential ceasing of pumping for the Drift-Platteville Aquifer. The MDH has prepared an attachment to this letter discussing MDH policy for polycyclic aromatic hydrocarbons (PAH). As noted, MDH endorses using the Potency Equivalency Factor (PEF) to determine cancer risk for PAH mixtures. The MPCA and U.S. EPA would like to establish the Cessation Concentrations using the best available scientific information.

In order to accommodate revisions of MDH policy, we propose using the HRL and HBV compounds and concentrations which are MDH policy at the time the cessation concentrations are evaluated, in order to accommodate revisions of MDH policy. This will avoid being locked into concentrations for specific contaminants that become outdated as new information is developed.

Compliance with Gradient Control Objective - Suitable cessation criteria also need to incorporate the objective of the gradient control system. The Reilly Tar Site remedial action system for the Drift-Platteville Aquifer includes two source control wells (W420 and W421) and three gradient control wells (W422, W434 and W439). Given the gradient control objective of effectively limiting spreading of contaminants into the bedrock valley, it is necessary to complete the following:

- Delineate the inferred portion of the Drift-Platteville Aquifer that contributes recharge to the bedrock valley;
- Characterize the respective capture zone for each control well to assess if contamination upgradient of the bedrock valley is being effectively controlled;
- Characterize the contaminant concentrations in ground water within the applicable capture zone(s) to determine if the levels exceed the cessation concentrations.

The MPCA and U.S. EPA will consider approving ceasing of pumping at individual gradient control wells, as long as it is demonstrated that contaminant concentrations in the portion of the aquifer influenced by the gradient control well does not exceed proposed cessation concentrations. We encourage use of existing pumping test analysis and historical monitoring well results to perform this characterization.

We are seeking a mutual understanding of a conceptual model governing contaminant transport toward and into the bedrock valley. It is not our intent to require rigorous numerical analysis to complete this characterization.

Based on our review of the extent of the monitoring well network, the MPCA and U.S. EPA anticipate the current network does not adequately characterize the contamination in the Drift-Platteville Aquifer to determine if levels are below the proposed cessation concentrations, particularly for the Drift Aquifer. Previous sampling results for wells and piezometers in the Drift may be useful to define the plume, but may not include results for individual PAH compounds. A compilation of historical results available within the subject area is necessary to characterize the plume upgradient of the bedrock valley. It is anticipated additional sampling will be necessary to characterize the current plume distribution for the proposed individual PAH standards. A work plan, subject to review and approval, is required prior to performing additional sampling. We encourage using existing wells and piezometers to collect the additional samples, to the extent practicable.

Assessment of Contaminant Spreading - In the event the MPCA and U.S. EPA approve ceasing of pumping at individual gradient control wells, it will be necessary to perform on-going monitoring to assess if the plume is migrating toward and into the bedrock valley. We are requesting a proposed plan to establish a network of wells in the Drift-Platteville Aquifer to assess continued compliance with cessation concentrations. The plan shall identify the wells to be sampled and sampling frequency for the compliance network. This may include monitoring of wells completed in the St. Peter Aquifer near the bedrock valley to track trends of contaminant concentrations.

Criteria to Resume Gradient Control - The MPCA approval of cessation of pumping will require establishing criteria to be used as an action level to resume operation of the gradient control well(s), as necessary to prevent contaminant spreading into the bedrock valley. Note that any future MPCA approval of cessation criteria will require a description of the methods to be used to suspend gradient control well operation, while maintaining the well(s) on a standby basis, in the event the well is needed in the future.

We would be pleased to meet with you at your request to discuss the content of this letter. If you have any questions regarding the project, please feel free to contact Nile Fellows at (651) 296-7299, or Paul Bulger at (651) 296-7827.

Sincerely,

N. R. Fellows

Nile R. Fellows
Project Manger
Site Remediation Section
Metro District

Paul Bulger for

Darryl Owens
Remedial Project Manager
Remedial Response Branch
U.S. Environmental Protection Agency

NRF/DO:csa

cc: Bill Gregg, ENSR
Carl Herbrandson, MDH

Minnesota Pollution Control Agency

October 3, 2000

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Charles Meyer, City Manager
City of St. Louis Park
5065 Minnetonka Boulevard
St. Louis Park, Minnesota 55416

Mr. Thomas Reilly, Jr., President
Reilly Industries
300 North Meridian Street, Suite 1500
Indianapolis, Indiana 46204-1763

RE: United States of America, et al. Vs. Reilly Tar & Chemical Corporation, et al.
File No. Civ. 4-89-468, Consent Decree - Remedial Action Plan (CD-RAP)
Section 9.2; **Drift-Platteville Aquifer Gradient Control Cessation Request**

Dear Mr. Meyer and Mr. Reilly:

The Minnesota Pollution Control Agency (MPCA) and U.S. Environmental Protection Agency (EPA) (Agencies) are in receipt of the following documents regarding the Drift/Platteville Aquifer gradient control system:

Letter prepared by ENSR, dated September 28, 1999, which proposed cessation criteria for gradient control wells W422 and W434.

Letter Report prepared by ENSR, dated April 21, 2000, which responded to the Agencies comment letter dated December 6, 1999.

The MPCA, EPA and Minnesota Department of Health (MDH) have reviewed the request to cease pumping at control wells W422 and W434. The request to ceases pumping was evaluated with respect to the remedial action objective for the Drift/Platteville gradient control system. This objective is to "limit the spread of contamination into the area delineated by the buried bedrock valley", generally south of Highway 7, near Wooddale Avenue. To evaluate the appropriate site information pertaining to achievement of the objective, the Agencies established four cessation criteria – cessation concentrations, compliance with gradient control objective, assessment of contaminant spreading, and criteria to resume gradient control. These four criteria were contained in the December 6, 1999, Agencies letter.

The Agencies hereby approve cessation of pumping at control well W422, effective upon reciept of this letter. The concentrations of PAH parameters in the ground water captured by W422, are below the numeric criteria established for the Drift/Platteville Aquifer. Control wells W420 and W421 are upgradient of W422 and appear to sufficiently capture the highly contaminated ground water immediately south of the former Reilly Site. We request you submit a letter documenting the termination of pumping at well W422, once the well pump is shut off.

The Agencies are unable to approve cessation of pumping at control well W434, at this time. Each control well is required to be pumped for a minimum of five years. Pumping at W434 was initiated in June 1997, thus needs to pump until June 2002 to meet this requirement. While the Consent Decree requirements are the primary reason to continue pumping of W434, the Agencies also evaluated W434 performance relative to the cessation criteria. Well W434 is immediately adjacent to the bedrock valley of concern. While the pumping rate is low and the resulting capture zone limited, the Agencies interpret this well as important to reduce the volume of contaminated ground water migrating into the bedrock valley. Upgradient monitoring wells W426 and W437, which have only been sampled once, have high contaminant concentrations and W434 is the only downgradient gradient control well. Thus, cessation of pumping in W434 does not satisfy the objectives of the gradient control cessation criteria.

Additional details concerning review of the report dated April 21, 2000, are included in the attachment to this letter. The rationale for our determinations stated above are also included.

We would be pleased to meet with you at your request to discuss the content of this letter. If you have any questions regarding the project please feel free to contact Nile Fellows or Paul Bulger (651/296-7827).

Sincerely,

Nile Fellows PRB

Nile Fellows
Project Manger
Site Remediation Section
Metro District
(651/296-7299)

Frederick K Campbell for

Darryl Owens
Remedial Project Manager
Remedial Response Branch
U.S. Environmental Protection Agency
(312/886-7089)

NF:DO:tf

Enclosure

cc: Bill Gregg, ENSR Consulting and Engineering
Virginia Yingling, Minnesota Department of Health

ATTACHMENT

Cessation Concentrations

The Agencies are in agreement with the City of St. Louis Park, that the concentrations established within the Minnesota Department of Health Health Risk Limits (HRL) and related Health Based Values (HBV) are suitable for evaluating potential ceasing of pumping for the Drift-Platteville Aquifer. The Agencies would like to establish the Cessation Concentrations as numeric values based on the best available scientific information. Therefore, we propose using the HRL and HBV compounds and concentrations, which are current MDH rules at the time the cessation concentrations will be evaluated. This will allow the ability to accommodate revisions of MDH rules.

The HRL and HBV applicable in the year 2000 are listed on Table 1 (attached). The MDH may revise the HRL or HBV for selected PAH compounds. The Agencies will not apply these potentially revised standards to the Reilly project until a formal document is issued by the MDH.

The Agencies also evaluated the change in total PAH concentration through time at individual wells. A risk-based concentration has not been established for total PAH, thus a numeric value was not included on Table 1. However, since a number of PAH compounds are routinely detected, and do not have an associated HRL or HBV, the Agencies consider the evaluation as valuable evidence when reviewing potential plume migration.

Compliance with Gradient Control Objective

The regional gradient for the Platteville Aquifer is generally sloping toward the southeast, as indicated on Figure 6-5 of the 1999 Annual Report. The gradient for the Drift Aquifer has a similar direction, but is more east-southeast. The gradient control objective is to effectively limiting spreading of contaminants into the bedrock valley. The portion of the Drift/Platteville aquifer, which flows toward the north extension of the bedrock valley, is roughly bounded by Oxford/Cambridge Street on the south and 31st Street on the north. The Glenwood Shale is eroded at the bedrock valley, and the upper aquifers appear to recharge the St. Peter Aquifer (USGS Water Resources Investigation Report 94-4204).

The estimated capture zone for the Drift control well W422 is depicted on Figure 7 of the ENSR report submitted in April 2000. The Agencies completed a qualitative review of this capture zone and the estimate is consistent with the conceptual model for the site. Well 422 captures water that is located downgradient of control well W420 and water generally south of Lake Street. These portions of the aquifer contain relatively low concentrations of contaminants. Thus, it is approvable to cease the pumping at Well W422. The risk evaluation completed by ENSR lends further support that the ground water in the capture zone for W422 does not represent a health risk.

Pumping at gradient control well W434 forms a small capture zone, as shown on Figure 7 of the ENSR report (April 2000). The Platteville aquifer has a zone of low permeability in this location, which limits the pumping rate and associated capture zone. Evaluation of the Platteville potentiometric surface contours suggests water flowing into the bedrock valley includes water located north of Highway 7 up to 31st street. Well W434 captures a portion of this water and is recommended to continue to be operated since it is the only gradient control well in the Platteville Aquifer.

The Platteville water quality in the area bounded by Oxford Street, Louisiana Avenue, a north boundary extending west from 34th Street, and Wooddale Avenue contains impacted water, with some wells at high concentrations. A number of the wells, particularly with high concentrations, were sampled for only one event. For instance wells W 426 and W437 indicate a hazard index greater than one, with W434 the only downgradient control well. Other wells obtain high concentrations of total PAH. Given the uncertainty of the PAH concentrations flowing toward the bedrock valley, the Agencies consider that continued gradient control at W434 is warranted.

<u>Assessment of Contaminant Spreading</u>

Following cessation of pumping at W422, an adequate monitoring well network is necessary to evaluate if the PAH plume in the upper aquifers expands or exceeds the numeric values. ENSR has proposed the well network for the Drift, Platteville and St. Peter aquifers. The Agencies have revised the well network, as listed on Table 2 (attached).

As part on the assessment monitoring, the Agencies request the sampling, as listed on Table 2, to further characterize the PAH concentrations in the aquifer upgradient of the bedrock valley. Many of these wells have not been sampled since the early 1990's. All wells listed on Table 2 shall be sampled on a semi-annual schedule, beginning in 2001. Following collection of two sampling events, the well network can be re-evaluated to determine if it is appropriate to add or delete wells from the sampling program. The well sampling outlined on Table 2, will replace the wells currently monitored for these aquifers in the 2000 Sampling Plan.

A meeting to discuss the monitoring well network for the Reilly site is scheduled for the week of October 2, 2000. The wells to be sampled will be discussed and negotiated. The agreed upon well network will be established in the 2001 Sampling Plan to be submitted at the end of October.

The samples shall be analyzed for PAH compounds. Wells that historically detect total PAH greater than 50,000 parts per trillion (ppt) are allowed to analyzed using detection limits in the ppb range. Wells with total PAH below 50,000 ppt shall be analyzed using detection limits in the ppt range. The compounds classified as carcinogenic PAH shall be the compounds used in the Benzoapyrene (BaP) equivalence calculation. These analysis and reporting criteria can be incorporated into the 2001 Sampling Plan.

<u>Criteria to Resume Gradient Control</u>

The City proposes using the numeric criteria established for cessation concentrations, shown in the attached Table 1, as suitable for determining when to resume gradient control pumping. The Agencies concur that these concentrations are appropriate. The Agencies also concur that the plume migration rate is slow enough to use the scheduled sampling analysis, frequency and reporting for making a decision about whether pumping needs to resume.

The approach of placing W422 on standby is acceptable. The existing pump in the well will be used periodically for sampling, also routine maintenance will be performed. Electrical and sanitary sewer connections will remain intact so that pumping can be resumed promptly, if necessary.

Table 1

Cessation Criteria for Drift/Platteville Gradient Control Wells

Parameter	**HRL**	**Cessation Concentration**
Carcinogenic PAH (Benzo-a-Pyrene) equivalents	0.05	0.05
Acenapthene	400	400
Anthracene	2000	2000
Fluoranthene	300	300
Fluorene	300	300
Napthalene	300	300
Pyrene	200	200

Concentrations are in units of micrograms per liter (ug/l), equivalent to parts per billion (ppb).
HRL = Health Risk Limit, established by the Minnesota Department of Health.

Table 2

Drift – Platteville – St. Peter Aquifers Monitoring Program

AQUIFER	WATER QUALITY SAMPLING	WATER LEVEL MONITOING
DRIFT	P109	W2
	P112	W10
	P307	W15
	P308	W19
	P309	W116
	P310	W128
	P311	W130
	P312	W135
	W11	P47
	W117	
	W136	
	W422	
	W427	
	W439	
PLATTEVILLE WELLS	W20	W1
	W27	W18
	W101	W19
	W131	W100
	W143	W120
	W426	W121
	W428	W124
	W431	W130
	W433	W424
	W434	
	W437	
	W438	
ST. PETER WELLS	SLP3	W408
	W24	P116
	W33	W129
	W122	
	W133	
	W409	
	W410	
	W411	
	W412	

Minnesota Pollution Control Agency

March 17, 2006

Mr. Charles Meyer, City Manager
City of St. Louis Park
5065 Minnetonka Boulevard
St. Louis Park, MN 55416

Mr. Thomas Reilly, Jr., President
Reilly Industries
300 North Meridian Street, Suite 1500
Indianapolis, IN 46204-1763

RE: Reilly Tar Superfund Site, Request for Approval of Cessation of Well 434

Dear Mr. Meyer and Mr. Reilly:

The Minnesota Pollution Control Agency (MPCA) received a request from William Gregg dated April 15, 2005 and received on April 19, 2005 to cease operation of Platteville Aquifer gradient control well W434 in accordance with Section 9.2 of the Consent Decree-Remedial Action Plan (CD-RAP). This request was also provided to the U.S. Environmental Protection Agency (U.S. EPA). In response to this request a time extension was requested by the Agencies to allow a response by June 20, 2005.

On June 20, 2005 a letter from the MPCA and EPA denied the request for cessation of well 434. A major reason in the denial of this request was the presence of vinyl chloride in the vicinity of Well 434. A meeting was held at the MPCA on July 13, 2005 to discuss this issue. At that time it was agreed to operate Well 434 while the MPCA did some further investigation for Volatile Organic Contaminants (VOC's) in the vicinity of the well.

On January 23, 2006, William Gregg sent a letter indicating that the City still wanted to cease operation of well 434. This letter came after the City had allowed the MPCA additional time to study the VOC plume in the area of well 434.

The City's letter of April 15, 2005 provided justification that the cessation criteria for Well 434 had been met as follows:

1. Cessation Concentrations. The contamination levels are below the Minnesota Department of Health (MDH) Health Risk Limits (HRL). Additionally, the Platteville aquifer is not used as a drinking water aquifer.

2. Compliance with Gradient Control Objectives. Well 434 has a very small capture area. Contamination levels are low, and well 421 is capturing the contamination that has shown at wells 426 and 437.

3. Assessment of Contaminant Spreading. Table 2 of the April 15, 2005 letter lists the wells to be sampled. In addition, as indicated in the 2006 sampling plan, well 434 will continue to be sampled. For 2006 this would be semi-annually. We are also requesting yearly PAH samples from the following wells that are located near well 434 to better enable us to monitor the ground water contamination in this area. Please sample well 120 in the Platteville aquifer and wells 128 and 135 in the Drift Aquifer.

4. Criteria to Resume Gradient Control. Table 1 of the April 15, 2005 letter contains cessation criteria for well 434. Should these criteria be exceeded, well 434 will need to be turned on again.

At this time, the Agencies concur that Well 434 has met the cessation criteria and is no longer needed to address the known PAH contamination from the Reilly Tar Site. The well can be turned off. However, as indicated in item four above, should the levels of contamination exceed the cessation criteria this well would have to be turned back on.

The MPCA is also requesting continued cooperation of the City in collecting VOC samples from the Reilly Tar monitoring well network. The VOC plume needs to be tracked and the City's help in collecting these samples will be appreciated.

Please inform the Agencies when well 434 is shut off. If you have any questions in this matter, please feel free to contact Nile Fellows at (651) 296-7299.

Sincerely,

Nile Fellows
Project Leader
Superfund Unit 1
Superfund and Emergency Response Section
Remediation Division

Darryl Owens
Project Manager
Superfund
U.S. EPA

NF/DO:csa

cc: Mike Rardan, City of St. Louis Park
Virginia Yingling, MDH
William M. Gregg, ENSR

Appendix C

Stormwater PAH Data

EVALUATION OF

GROUNDWATER TREATMENT
AND
WATER SUPPLY ALTERNATIVES
FOR
ST. LOUIS PARK, MINNESOTA

Prepared for

Minnesota Pollution Control Agency

VOLUME 1 OF 2 - SUMMARY REPORT

By

CH2M HILL
Milwaukee, Wisconsin

BARR ENGINEERING CO.
Minneapolis, Minnesota

NOVEMBER, 1983

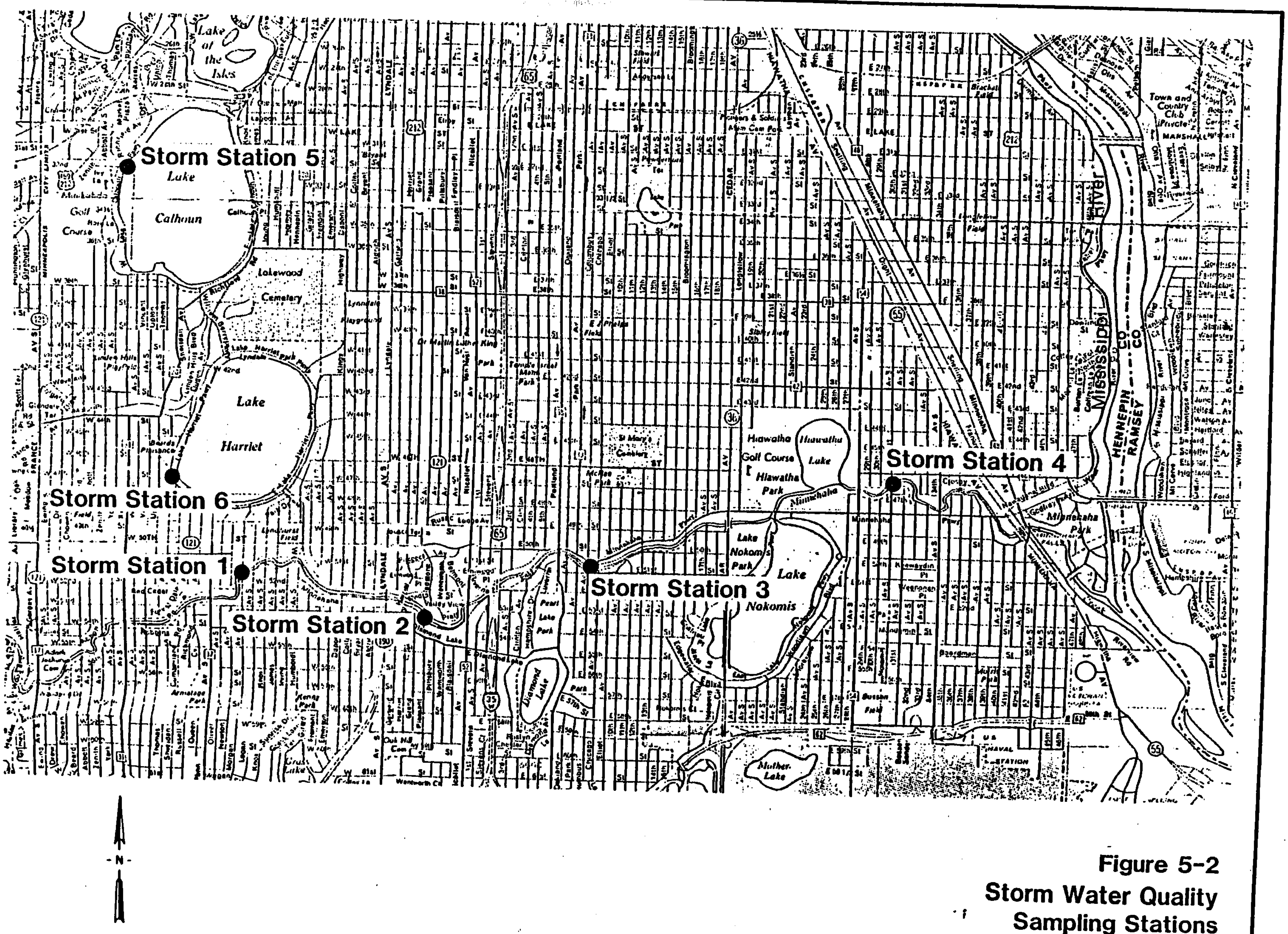


Figure 5-2
Storm Water Quality Sampling Stations

Table 5-4
ANALYSIS OF STORMWATER RUNOFF SAMPLES

PARAMETER (ALL VALUES IN ng/l)	Storm 1	Storm 2	Storm 3	Storm 4	Storm 4 Duplicate	Storm 5	Storm 6
DATE:	10/10/83	10/10/83	10/10/83	10/10/83	10/10/83	10/10/83	10/10/83
ANALYSIS BY:	CH2M HILL	CH2M HILL	CH2M HILL	CH2M HILL	CH2M HILL	CH2M HILL	CH2M HILL
ANALYTICAL EQUIPMENT:	GC/MS	GC/MS	GC/MS	GC/MS	GC/MS	GC/MS	GC/MS
NAPHTHALENE	320	250	380	370	420	150	340
1-METHYLNAPHTHALENE	190	260	280	460	580	140	380
2-METHYLNAPHTHALENE	300	540	570	800	1,000	260	750
ACENAPHTHYLENE							
ACENAPHTHENE	54	67					40
FLUORENE	91	61	40	35			76
ANTHRACENE	67	30		25	32		44
PHENANTHRENE	340	230	230	170	220	85	300
PYRENE	190	130	110	108	120	52	120
FLUORANTHENE	290	170	170	150	160	54	160
PHENYLNAPHTHALENE							
1,2,6,7-TETRAHYDROPYRENE							
BENZO(a)ANTHRACENE*	59	34	28	34	38		
9,10-BENZPHENANTHRENE							
CHRYSENE*	130	66	52	63	86		66
BENZO(b&k)FLUORANTHENE*	130	62					
BENZO(a)PYRENE*							
BENZO(e)PYRENE							
BENZO(j)FLUORANTHENE*							
PERYLENE							
BENZO(g,h,i)PERYLENE							
INDENO(1,2,3-cd)PYRENE*							
O-PHENYLENEPYRENE							
DIBENZO(a,h)ANTHRACENE*							
TOTAL CARCINOGENIC PAH'S	319	162	80	97	124	-	66
TOTAL "OTHER" PAH'S	1,842	1,738	1,780	2,118	2,532	741	2,210
NITROGEN HETEROCYCLES							
ACRIDINE							
CARBAZOLE	400	140	190	100	120	32	240
INDOLE	110	110	130		67		
PHENANTHRIDINE							
QUINOLINE	190	110	120	100	99	61	130
SULFUR HETEROCYCLES							
BENZO(b)THIOPHENE							
DIBENZOTHIOPHENE							
OXYGEN HETEROCYCLES							
DIBENZOFURAN							
MISCELLANEOUS							
BIPHENYL	32	56			33		
2,3-DIHYDROINDENE	72		52	66	66	39	65
INDENE	34	69	34	28	34		
AROMATIC AMINES							
ANILINE							
1-AMINONAPHTHALENE							
2-AMINOBIPHENYL							

Note: All compounds found at less than detection limit have been deleted.

GLT315/8

Appendix D

Platteville Formation Hydrostratigraphy

The Geological Society of America
Field Guide 24
2011

Hydrostratigraphy of a fractured, urban aquitard

Julia R. Anderson
Anthony C. Runkel
Robert G. Tipping
Minnesota Geological Survey, 2642 University Ave. W, St. Paul, Minnesota 55114-1032, USA

Kelton D.L. Barr
Braun Intertec Corporation, 11001 Hampshire Ave. S, Minneapolis, Minnesota 55438, USA

E. Calvin Alexander Jr.
Department of Earth Sciences, 310 Pillsbury Dr. SE, University of Minnesota, Minneapolis, Minnesota 55455-0231, USA

ABSTRACT

This one-day trip provides an overview of the hydrostratigraphic attributes of the Platteville aquitard in the Twin Cities Metropolitan area. As a shallowly buried, extensively fractured carbonate rock in an urban setting, vulnerable to contaminants, the Platteville has been the subject of a wide variety of geomechanical and hydrogeologic studies over the past few decades. This work, combined with our own borehole geophysics and outcrop observations, has led to a more comprehensive understanding of the Platteville. The field trip will provide examples of what we have learned from these many different data sources, which collectively lead to a characterization of the Platteville as a complex "hybrid" hydrogeologic unit. Under certain conditions, and from one perspective, it can serve as an important aquitard that limits vertical flow, whereas in other conditions, and from another perspective, it is best considered a karstic aquifer with bedding-plane parallel conduits of very high hydraulic conductivity that permit rapid flow of large volumes of water. One particular focus of the trip will be demonstration of what appears to be predictability in both vertical and bedding-plane fracture patterns that in turn provides some degree of predictability of flow paths in three dimensions. These relationships appear to be operative for the Platteville in other parts of the Upper Midwest where the Platteville is shallowly buried. We will demonstrate that effective management of such complex, karst, "hybrid," hydrogeologic units requires a sophisticated, nuanced understanding of their heterogeneous behavior.

Anderson, J.R., Runkel, A.C., Tipping, R.G., Barr, K.D.L., and Alexander, E.C., Jr., 2011, Hydrostratigraphy of a fractured, urban aquitard, *in* Miller, J.D., Jr., Hudak, G.J., Wittkop, C., and McLaughlin, P.I., eds., Archean to Anthropocene: Field Guides to the Geology of the Mid-Continent of North America: Geological Society of America Field Guide 24, p. 457–475, doi:10.1130/2011.0024(22). For permission to copy, contact editing@geosociety.org.

INTRODUCTION

The Paleozoic bedrock of the Twin Cities Metropolitan (TCM) area of Minnesota, USA, provides over one-half of the drinking water for its 3 million citizens. Increasing demand for groundwater and concerns about contamination of deep aquifers have led to a number of studies over the past 20 years that have significantly improved our understanding of this aquifer system, resulting in redefinition of the classic divisions of the section into regional aquifers and aquitards on the basis of hydrostratigraphic attributes (Runkel et al., 2003, 2006; Tipping et al., 2006). Strong emphasis has been placed on the stratigraphic context of macropores in an effort to improve the predictability of fracture-dominated flow.

Although aquifers in the bedrock system are now relatively well characterized, our understanding of the intervening aquitards remains poor, a non-provincial problem in hydrogeology (Bradbury et al., 2006). Methods for characterizing their physical properties are not well developed, especially the acquisition of data that provide insight into vertically oriented features. Limitations to characterizing vertical fractures are perhaps the first-order problem that has hindered our ability to evaluate the integrity of aquitards.

This field trip provides an overview of our ongoing research on the Late Ordovician Platteville Formation in the central part of the TCM area (Figs. 1 and 2), where it is traditionally considered the middle part of the Decorah-Platteville-Glenwood Aquitard (Kanivetsky, 1978). Here, the Platteville is a shallowly buried (<30 m, 100 ft) carbonate-dominated formation that occupies a position near the top of the Paleozoic bedrock sequence of the Twin Cities basin, a broad regional depression developed in the northernmost major preserved extent of Paleozoic bedrock in the Upper Mississippi Valley region (Mossler, 1972). Anticlines, synclines, and faults in this basin are attributed to reactivation of structures from the Mesoproterozoic Midcontinent Rift. Strata were deposited in a broad, shallow, near-equatorial epeiric ramp referred to as the Upper Mississippi Valley epeiric ramp and consist mostly of sandstone, siltstone, carbonate, and shale.

Our research integrates a variety of data sets for the purpose of constructing a conceptual model (Fig. 3) that improves predictability of groundwater flow in the Platteville Formation. As a shallowly buried, fractured bedrock layer in an urban setting, the Platteville is contaminated at a large number of sites that have been comprehensively studied to develop remedial strategies. Subsurface hydrogeologic information from these sites includes results from discrete-interval packer tests, borehole geophysics (including flowmeter), larger scale aquifer tests, potentiometric surface mapping, and dye traces. The Platteville Formation also commonly plays an important role in urban engineering projects, and data acquired from underground excavations that expose bedding plane views of vertical fractures and quantify leakage through them are used to provide insight into a third dimension. Our own research has also added outcrop context, including characterizing the initiation and termination of vertical fractures in a mechanical stratigraphic analysis and providing stratigraphic context for the position of active conduits (i.e., springs).

Our results thus far on this and other Paleozoic bedrock units traditionally regarded as aquitards in this region indicate that they are best considered "hybrid" hydrogeologic units. Even intervals of strata a few meters thick can significantly limit vertical flow, serving to protect underlying groundwater from contamination, but they can also contain bedding plane conduit(s) of very high hydraulic conductivity with the potential to accommodate rapid flow of large volumes of contaminants. We informally refer to such bedrock layers as "aquitardifers." However, despite this complex heterogeneity, we show that with sufficient data there appears to be predictability in both vertical and bedding plane fractures in relatively undeformed, layered sedimentary rock, which in turn provides some degree of predictability of flow paths in three dimensions.

TRIP SUMMARY

This field trip focuses on the hydrostratigraphy of the Platteville Formation, specifically the fracture attributes that dominate its groundwater flow system. The trip includes nine stops along the Mississippi River and distal parts of its tributaries (Fig. 1). Natural exposures of the Platteville at each of the first eight stops are used to illustrate the fundamental stratigraphy of the formation, its material properties, and vertical and bedding-plane fracture patterns, integrated in a mechanical stratigraphic analysis. The final stop, at the Minnesota Library Access Center (MLAC) underground archive building, will include a summary of our current conceptual model of the Platteville based on our observations at previous stops, combined with information gleaned from the construction and remediation at the library.

FIELD TRIP STOPS

Stop 1. Shadow Falls: Ordovician Formations of the Twin Cities Metropolitan Area

Location: Stop 1 is situated at the west end of Summit Avenue at the intersection with East River Road. UTM coordinates of Stop 1 parking area: 484,368 E/4,976,418 N. TRS location: T. 28 N, R. 23 W, sec. 5, SE, NW. All UTM coordinates are given in North American Datum 83, Zone 15.

Directions: From Minneapolis, drive east on Interstate 94. Exit on Vandalia Street/Cretin Avenue (exit 237); turn right on Cretin Avenue. Turn right on Mississippi River Boulevard and take an immediate left to stay on Mississippi River Boulevard. Turn right into the Shadow Falls parking area at Summit Avenue.

Description: This stop provides an excellent and accessible view of the Late Ordovician succession of sandstone, shale, and carbonate strata in the TCM area, including the upper St. Peter Sandstone, Glenwood Formation, Platteville Formation, and lower Decorah Shale (Fig. 2). The well-known medium- to fine-grained, well-sorted, white, mature quartz sandstone of the St.

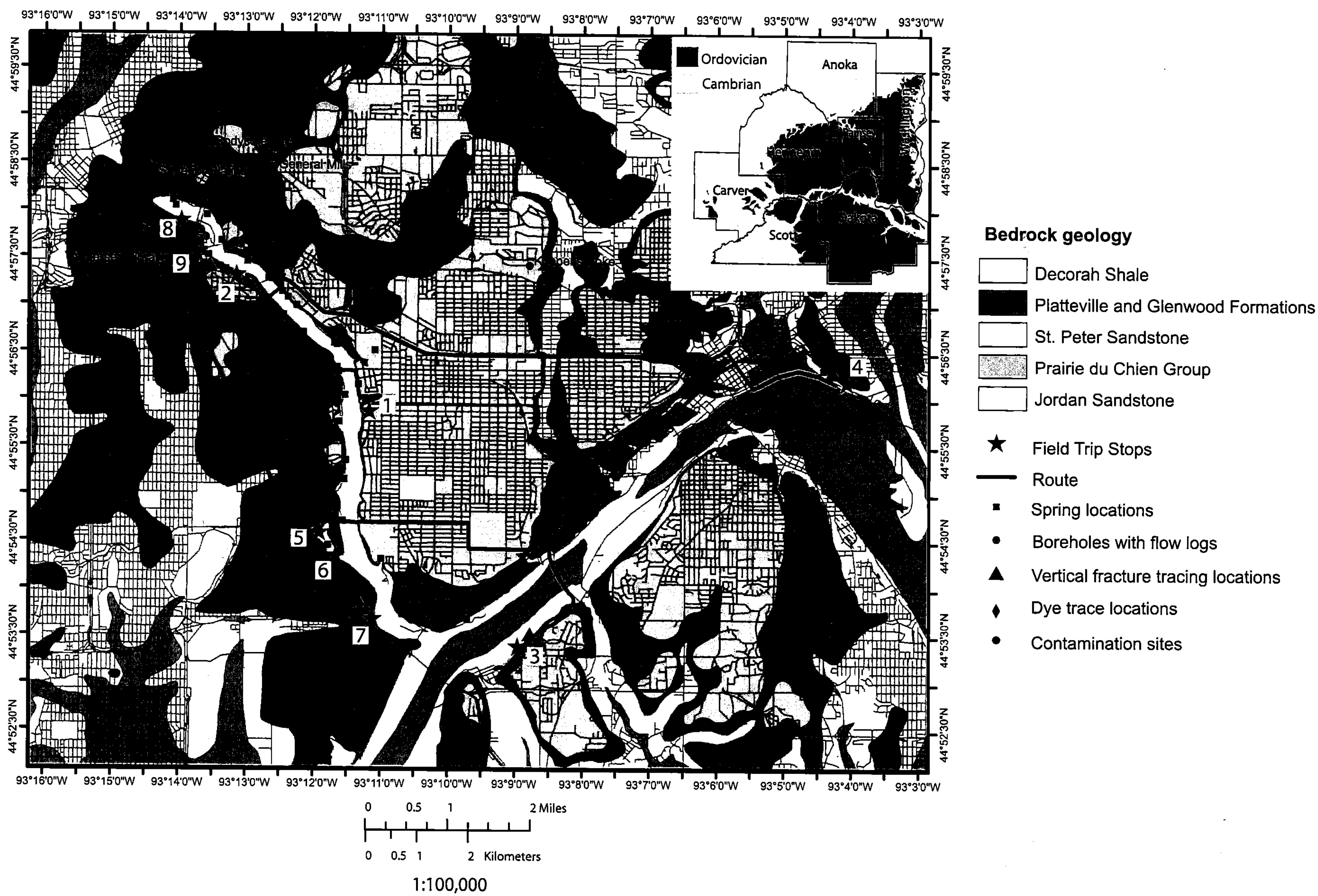


Figure 1. Map of the Twin Cities Metropolitan area, showing springs, boreholes with flow logs, vertical fracture traces, dye traces, major contamination sites in the area with extensive hydrogeologic data, and the Paleozoic bedrock geology. The field trip route and stops are also shown. The inset illustration shows the general outline of the Twin Cities basin.

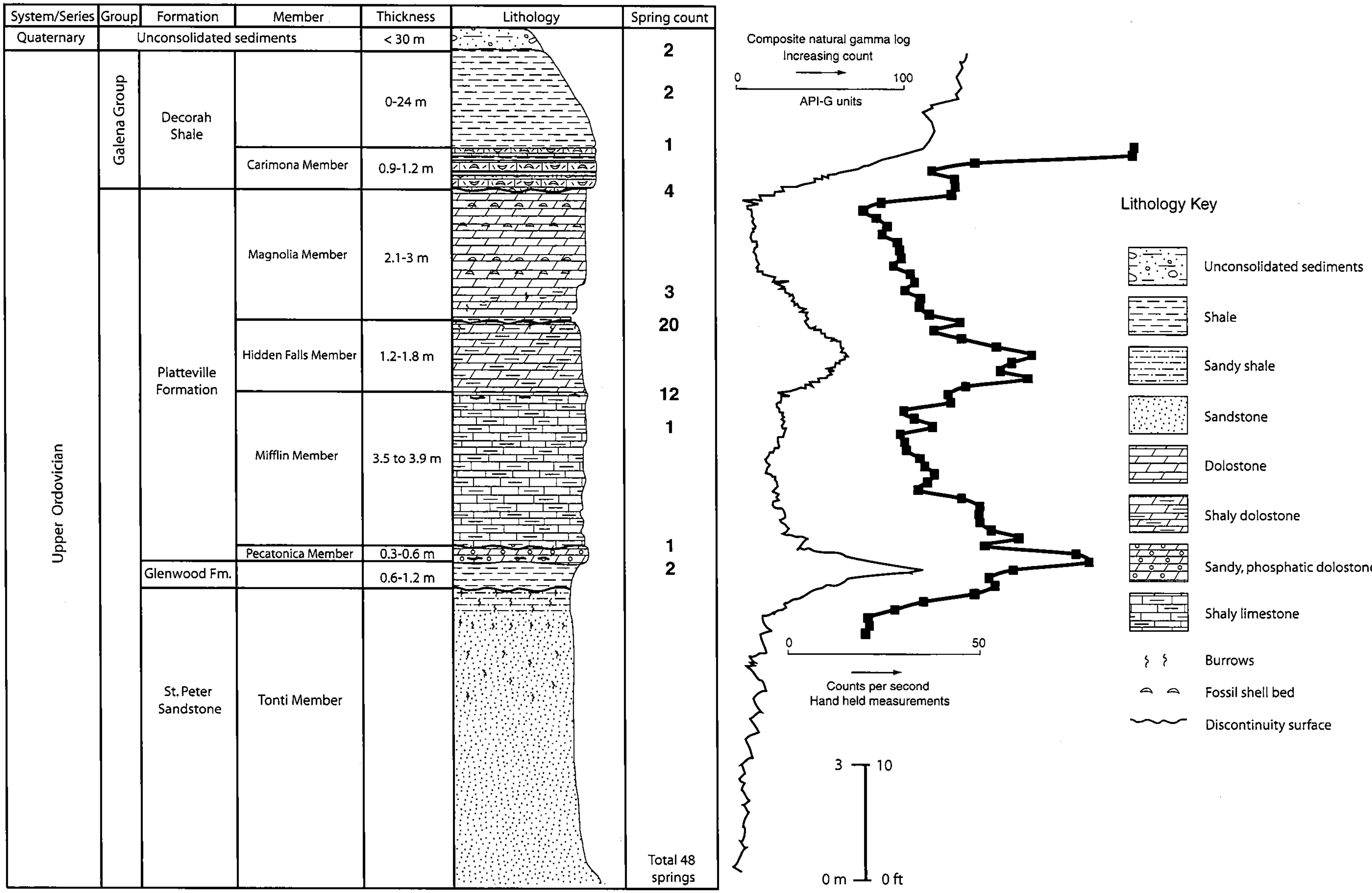
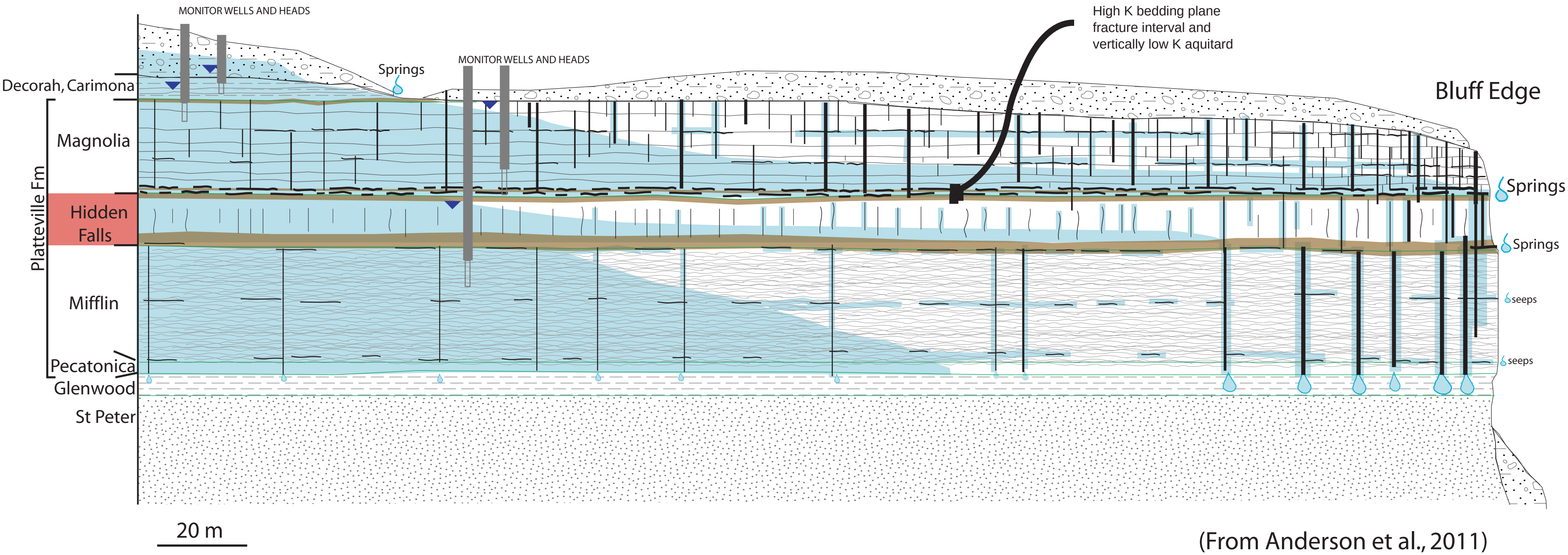


Figure 2. Generalized stratigraphic column, depicting the lithology, thickness, and nomenclature for the Upper Ordovician formations in the Twin Cities Metropolitan area. The spring count lists the number of springs emanating from a specific stratigraphic interval. The composite natural gamma log (units in API-G) is the log shown on the left alongside the log constructed from a handheld gamma-ray scintillometer (measurements in counts per second) shown on the right.

HYDROSTRATIGRAPHIC CONCEPTUAL MODEL OF THE PLATTEVILLE FORMATION



(From Anderson et al., 2011)

Unconsolidated sand, gravel, clay

Sandstone

Shale

Carbonate

Carbonate bedding styles

Water

Discrete aquitard (shown only for Platteville Fm. and lower Decorah Shale)

Vertical to subvertical fractures

Bedding parallel fractures

Peter forms the lowest part of the exposure. The greenish-gray, phosphatic, condensed shale of the Glenwood Formation lies stratigraphically between the St. Peter Sandstone below and the carbonate-dominated Platteville Formation above and is generally 0.6–1.2 m (2–4 ft) thick.

In the Twin Cities, the Platteville Formation ranges from ~7.0–8.8 m (26–29 ft) in thickness and is subdivided into four members, from bottom to top: Pecatonica, Mifflin, Hidden Falls, and Magnolia (Mossler, 2008). These are distinguished mainly by lithology and bedding style and correspond to major depositional facies of the formation (Fig. 2). The Pecatonica Member is a thin bed of burrowed, reworked, fossiliferous dolostone only 0.3–0.6 m (1–2 ft) thick. It commonly contains quartz sand, phosphate clasts and bored hardgrounds (centimeter-sized discontinuous surfaces of synsedimentary lithification commonly bored into by animals on the seafloor). The hardgrounds are regionally traceable bedding planes. One is present at the contact with the Mifflin Member, and the other is 5 cm below, within the Pecatonica. The Mifflin Member is a wavy-bedded, nodular, fossiliferous, heavily bioturbated limestone. Ranging from 3.5 to 3.9 m (11 to 13 ft) thick, it is the thickest member within the Platteville. Very thin, siliciclastic-rich carbonate beds are interbedded within the nodular, bioturbated limestone, giving it an alternating dark-gray and light-gray coloration pattern. The Mifflin is overlain by a dolomitic, phosphatic, argillaceous carbonate known as the Hidden Falls Member. It is massive and nonfossiliferous except for sporadic thin, fossiliferous lenses. The Hidden Falls Member ranges from 1.2 to 1.8 m (4 to 6 ft) thick and is recessive in outcrop, especially in the lower part. The top of the Hidden Falls is marked by a laterally extensive, burrowed, *(Chondrites)* diastemic surface. The Magnolia Member overlies the Hidden Falls. It is 2.1–3 m (7–10 ft) thick and is characterized by 2–5 cm coquina layers spaced about every 30 cm in an otherwise nonfossiliferous dolomitic mudstone. The lowermost Magnolia, directly above the contact with the Hidden Falls, is composed of several interbeds of carbonate, argillaceous carbonate, and fossiliferous carbonate, and, as we will see at subsequent field trip stops, it plays an important hydrostratigraphic role within the Platteville Formation.

Gamma logs acquired using a handheld gamma-ray scintillometer on this outcrop allows us to recognize individual members of the Platteville on the numerous borehole geophysical logs from the TCM area (Fig. 2). This was an immensely useful tool for correlating internal Platteville stratigraphy to high-resolution hydrogeologic data such as electromagnetic (EM) flowmeter logs. As we proceed throughout the day we'll see several examples highlighting the strong correlations between stratigraphic units, fracture network development, and groundwater flow paths in this "hybrid" hydrogeologic unit.

Stop 2. St. Mary's Spring: Platteville Springs and Their Stratigraphic Occurrence

Location: Stop 2 is along West River Parkway near the West Bank of the University of Minnesota campus beneath what was formerly called St. Mary's Hospital. UTM coordinates of Stop 2 parking area: 481,835 E/4,979,341 N. TRS location of parking area: T. 29 N, R. 24 W, sec. 25, NE, SE. UTM coordinates of the spring: 481,560 E/4,979,414 N. TRS location of the spring: T. 29 N, R. 24 W, sec. 25, NW, SE.

Directions: From Stop 1 continue northward on Mississippi River Boulevard. Turn right following signs for westbound Lake Street. Take a right onto West River Parkway and travel northbound. We will park off of West River Parkway in a parking area for Lower Riverside Park and walk along the bike path (northwest) toward the spring.

Description: Although the Platteville Formation is composed chiefly of carbonate rock with very low matrix permeability (ranging from 10^{-7} to 10^{-4} md; hydraulic conductivity 2×10^{-10} ft/d to 2×10^{-7} ft/d) (Runkel et al., 2003), and traditionally has been classified as an aquitard, wells open to the formation across the TCM area commonly have yields adequate for domestic needs, and hydrogeologic investigations have documented at least local areas with very high hydraulic conductivity (e.g., Liesch, 1973; Barr Engineering, 1983a; Peer Environmental and Engineering Resources, Inc., 1999). Secondary pores in the Platteville accommodate flow both vertically and horizontally. Vertical secondary pores include fractures typical of stress release conditions as well as vertical joints that are part of a large-scale orthogonal system oriented northeast-northwest. Horizontal pores are represented by bedding-plane conduit networks concentrated along discrete stratigraphic intervals, which are the focus of this stop.

Bedrock along the Mississippi River Valley from the confluence with the Minnesota River at Fort Snelling and upstream to St. Anthony Falls was only relatively recently exposed. The valley was cut by a retreating waterfall, now St. Anthony Falls, beginning ~12,000 yr ago after the most recent ice age, where it existed as a tributary to Glacial River Warren. This specific portion of the valley near St. Mary's spring was cut ~2500 yr ago (Wright, 1972). Today the valley includes a large number of springs that discharge from this incised bedrock. As part of our ongoing research, we have examined all mapped springs along this stretch of the river and documented their stratigraphic position within the Platteville and adjacent units. Of the 48 springs we've examined, the greatest percentage (42%) discharge at the contact between the Hidden Falls and Magnolia Members (Fig. 2). The contact between the Hidden Falls and Mifflin Members has the second greatest percentage of discharging springs (25%). The remaining springs discharged at several other stratigraphic positions but appear to be statistically insignificant (8% or less). St. Mary's spring (Fig. 4) is one of the best examples of a high flow, 12–15 gallons per minute (gpm), spring that discharges at a discrete bedding plane conduit at the Hidden Falls–Magnolia contact. The preferential stratigraphic position of springs at this contact is consistent with observations from the deeper subsurface. Engineering and hydrogeologic investigations at a number of sites across the TCM area have documented a discrete high hydraulic conductivity interval approximating the Hidden Falls and Magnolia contact (Barr Engineering, 1983b; Peer Environmental and Engineering Resources, Inc., 1999).

In an effort to evaluate the relationship between the stratigraphic position of springs and groundwater flow paths in the deeper subsurface, away from effects of a heavily fractured bluff edge, we collected a series of borehole geophysical logs from eight monitoring wells open to the Platteville Formation on the West and East Banks of the University of Minnesota campus (Fig. 1). The logging included EM flowmeter tests under ambient and stressed conditions during which water was injected at rates between ~0.8 and 10 gpm (Fig. 5). Video, caliper, and natural gamma-ray logs were also collected to recognize bedding plane fractures and determine their precise stratigraphic positions. Six wells of the eight had a single bedding plane fracture that dominated hydraulics, all at the Hidden Falls and Magnolia contact (Fig. 6). Hydraulic conductivities calculated for the Hidden Falls and Magnolia bedding plane conduit from injection in these wells ranged from 300 ft/d to 47,000 ft/d (Fig. 6). One of these six wells had a second bedding plane fracture that was hydraulically active, at 0.6 m (2 ft) above the Hidden Falls and Magnolia contact within the lower Magnolia Member. This fracture did not appear to dominate flow when we injected, although it did have a high hydraulic conductivity value of 2000 ft/d. Two of the eight tested wells had very different results. One of the wells is cased below the top of the Hidden Falls Member, open to the middle of the Hidden Falls and the upper part of the Mifflin Members. Hydraulic conductivity is so low in this borehole that we were unable to achieve a static head during injection. The other well is open to the Hidden Falls and Magnolia boundary, but there does not appear to be a bedding plane conduit at that horizon, and injected water exited the borehole directly at the base of the casing, stratigraphically within the middle of the Magnolia Member.

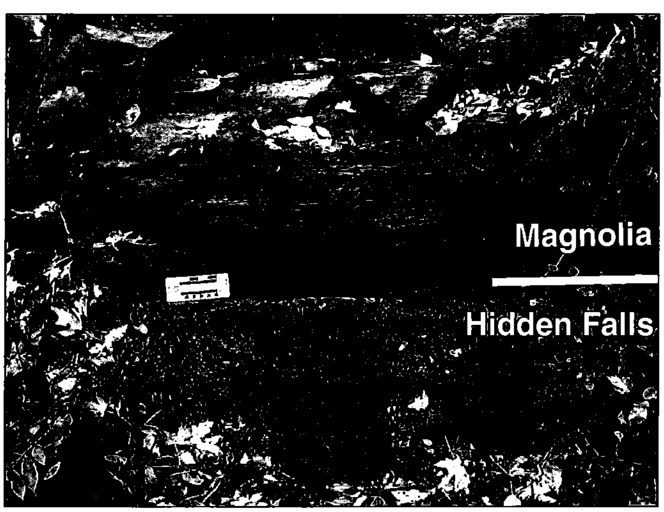


Figure 4. Photograph showing a close-up view of St. Mary's spring discharging from the Hidden Falls and Magnolia bedding plane contact. The scale object is 16 cm long.

In this case, water may be leaving at an opening between the borehole wall and the well casing.

Results from correlating spring positions with stratigraphic intervals is consistent with the borehole flowmeter logging results, both demonstrating preferential development of bedding plane conduits at the Hidden Falls–Magnolia contact. However, the outcrop results do appear to differ in that a relatively large percentage (25%) of springs emanate from the base of the Hidden Falls Member, a stratigraphic position for which subsurface conduits have not been recognized in our flowmeter logging, and have only rarely been recognized in other borehole hydrogeologic tests. Our current hypothesis to account for this discrepancy is that springs emanating below the top of the Hidden Falls Member may be attributed to a step-down effect at the bluff edge, where connectivity of vertical and bedding plane fractures are enhanced. It is possible that groundwater that travels along the Hidden Falls and Magnolia conduit across most of the subsurface extent of the Platteville steps stratigraphically down within meters of the bluff edges. We will see an example of a possible "step-down spring" at Stop 8, and will discuss support for this hypothesis later during the field trip.

Stop 3. Mendota Bike Trail: Mechanical Stratigraphy of the Platteville Formation

Location: Stop 3 is in Mendota Heights along the Mendota bike trail. We will park off Highway 13 where the trail intersects the highway. UTM coordinates of Stop 3 parking area: 487,417 E/4,970,516 N. TRS location of the parking area: T. 28 N, R. 23 W, sec. 27, NE, NW. UTM coordinates of the outcrop: 478,900E/4,970,964N. TRS location of the outcrop: T. 28 N, R. 23 W, sec. 22, SE, SE.

Directions: From Stop 2, turn around traveling south on West River Parkway and veer right, up the hill, to E Franklin Avenue. Take a right on Riverside Avenue and turn right onto eastbound Interstate 94. Exit onto southbound I-35 E/Kellogg Boulevard and follow signs for southbound I-35 E. From I-35 E, take the Highway 13 exit, turning right. We will park off of Highway 13 at the trail crossing and walk northbound on the trail to the exposure.

Description: Vertical fracture patterns in layered, undeformed rocks such as the Platteville are controlled by stratigraphic features. Vertical fractures typically initiate within a stratigraphic unit, spanning its entire thickness, referred to as a mechanical unit, and terminate at distinct stratigraphic horizons, known as mechanical interfaces. Stratigraphic features such as unit thickness, bedding thickness, and strength all play a key role in determining the trace length and spacing of vertical fractures. Ductile beds such as shale and other types of weak beds and interfaces commonly are preferential termination horizons for vertical fractures. Defining these units and interfaces is known as mechanical stratigraphy, which can provide insight into fracture network development and improved prediction of fluid flow pathways (Underwood et al., 2003; Cooke et al., 2006).

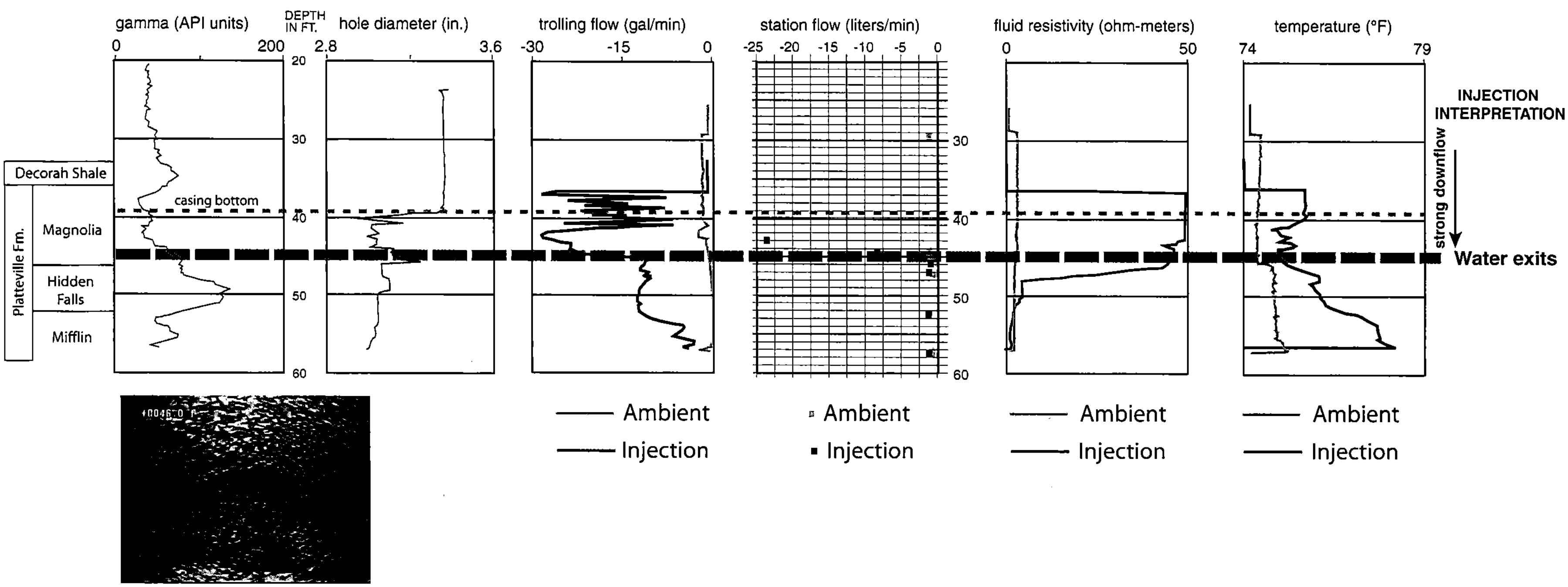


Figure 5. Example of the geophysical and hydraulic data collected from a monitoring well on the East Bank of the University of Minnesota campus (well no. 664362). There was no measurable ambient flow in this well. Water was injected in this hole at a rate of 10 gpm, and all water exited the borehole at a depth corresponding to a caliper deflection and bedding plane fracture in the video log at about 14 m (46 ft). Gray lines indicate measurements from ambient conditions, and black lines reflect injection conditions. Inset photograph is a still shot from the video log of the fracture that accepted water.

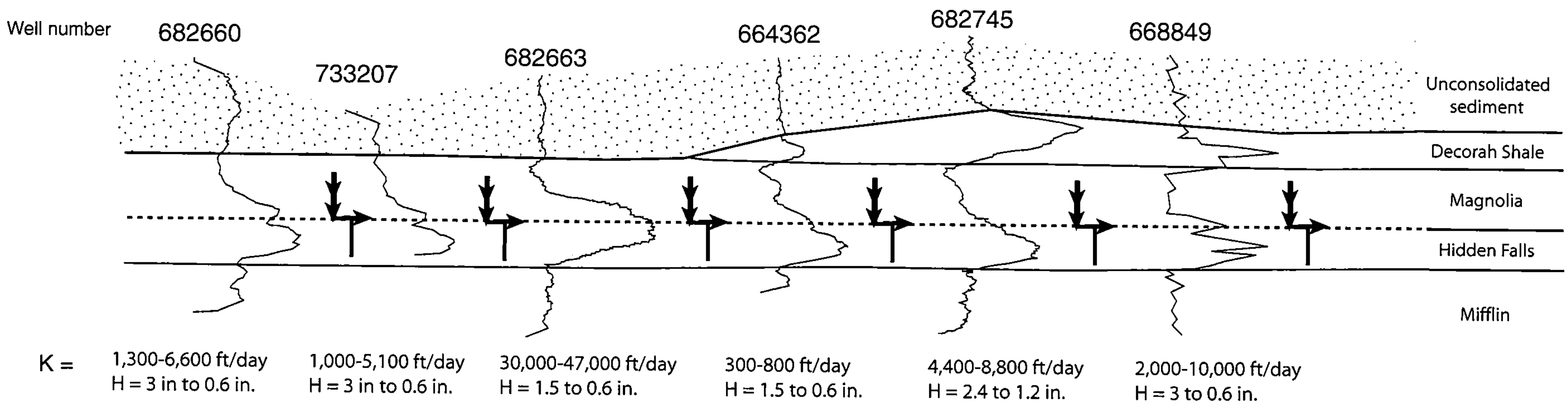


Figure 6. Correlated gamma logs of the six wells on the West and East Banks of the University of Minnesota campus, with a bedding plane fracture that dominated hydraulics in the borehole at the Hidden Falls–Magnolia contact, and their hydraulic conductivity values, ranging from 300 to 47,000 ft/d. H—fracture height, which represents the range of possible fracture apertures estimated from the video and caliper logs.

Mapping vertical fractures on exposure surfaces is a technique used in mechanical stratigraphy to characterize fracture density and termination horizons. Stop 3 is the most accessible, well-exposed outcrop of three in the TCM area (Fig. 7), where we have mapped vertical fractures in the Platteville Formation. Results at this locality show that the members of the Platteville each have a distinct style of vertical fracture density and spacing. The Magnolia Member has a high density of vertical to subvertical fractures with a wide range in trace length, creating a "blocky" texture. The Hidden Falls Member has a very high density of vertical to subvertical, straight to curvilinear fractures that are most abundant in the upper part of the unit. The Mifflin Member has a relatively wide spacing of vertical, straight fractures with long traces that typically extend through the entire thickness of the member. The Pecatonica has a narrower spacing of vertical, straight fractures with traces that span the thin bed. The Pecatonica is covered in the Figure 7 area but is exposed in other areas along this trail and at Stop 4. The members of the Platteville act as mechanical units, and the contacts between the members typically terminate vertical fractures, acting as mechanical interfaces. Individual vertical fractures extending through the entire formation are rarely present at some highly weathered outcrops.

Vertical fractures preferentially terminate at the Hidden Falls and Magnolia contact as well as near the base of the Hidden Falls. The Hidden Falls Member has a number of material properties differing from members above and below that may account for preferential termination of vertical fractures. Internally it is massive, without individual centimeter-scale beds characteristic of the Magnolia and Mifflin, as indicated by the conchoidal fractures characteristic of the member. It contains a higher percentage of siliciclastic material, largely clay and silt (especially in the middle part of the member), and on weathered exposures the densely fractured, small, blocky texture of the Hidden Falls is more similar to outcrops of relatively ductile shale, such as the Glenwood, than to brittle carbonate rock. Tensile- and compressive-strength values for the Hidden Falls, based on samples from a number of sites in the TCM area, average ~12,000 psi, ~40% lower than values for the Mifflin and Magnolia (CSC Joint Venture, 1985). The coincidence of preferential termination of vertical fractures with preferential development of bedding plane conduit(s) at the top of the Hidden Falls Member may also be indicative of a cause and effect relationship whereby bedding plane conduits at this position served as a weak mechanical interface where vertical fractures terminated.

Stop 4. Shepard Road: A Large Cliff-Top View of Vertical Fractures in the Platteville

Location: Stop 4 is a short stop along Shepard Road; we will park off the road to view the large exposure. UTM coordinates of Stop 4: 494,938 E/4,977,071 N. TRS location: T. 28 N, R. 22 W, sec. 4, NW, NW.

Directions: From Stop 3 continue back onto Highway 13 toward I-35 E. Head north on I-35 E. Exit on Shepard Road and take a right. Exposure is ~5 mi down Shepard Road on the north side of the road.

Description: This stop provides the most expansive view of the Platteville, Glenwood, and upper St. Peter formations in the area (Fig. 8A). Fracture characteristics here are similar to those at the Mendota locality (see Stop 3), where vertical fractures preferentially terminate at the top and near the base of the Hidden Falls. All three sites at which we have traced fractures in detail, and casual observations at several other, less well exposed sites in the TCM area, display preferential termination at these two stratigraphic intervals, suggesting that this is a regional and predictable phenomenon.

The spring, borehole, and fracture data we've compiled so far identify the Magnolia–Hidden Falls contact as a key stratigraphic position for groundwater flow. From a horizontal perspective it corresponds to the most prevalent high hydraulic-conductivity conduit. It also represents a mechanical interface or bed that has inhibited propagation of vertical fractures, which results in the strata directly below having potential to serve as an aquitard in a vertical direction. The lowermost part of the Hidden Falls Member, also an interval of preferential joint terminations, may similarly serve as a stratigraphically discrete aquitard. The outcrop and subsurface hydrogeologic expressions of this phenomenon is the presence of springs and water table aquifers perched preferentially in this relatively thin part of the Platteville Formation. Nested monitor wells similarly reflect vertical resistance to flow across the Hidden Falls, with heads above and below known to differ by as much as ~3 m (Fig. 3) (Braun Intertec Corporation, 2011). We have recently started collection of head data from Platteville wells, and preliminary results reveal an abrupt change in head corresponding to the Magnolia–Hidden Falls contact (Fig. 8B).

Stop 5. Minnehaha Falls Park Area: Lunch at Sea Salt with Discussion

Location: Stop 5 is in Minnehaha Falls Park. UTM coordinates of Stop 5: 483,396 E/4,973,646 N. TRS location: T. 28 N, R. 23 W, sec. 18, SE, NE.

Directions: From Stop 4 continue back on Shepard Road heading west. Continue on Shepard Road ~9 mi and follow signs toward Mississippi River Boulevard. Take a right onto Ford Parkway and head west over the Mississippi River. Turn left onto 46th Avenue S and right onto Godfrey Road; Minnehaha Falls Park is on the left.

Description: Here we will be eating lunch at Sea Salt Eatery in the park. There will be time to discuss what we have viewed so far on the field trip and explore Minnehaha Falls. The stream flows over the Platteville limestone, capping the Glenwood shale and St. Peter Sandstone.

Stop 6. Fort Snelling Bike Trail: Platteville Conduit Development

Location: Following lunch we will drive to the south end of the park area and walk down the Fort Snelling bike trail to a small

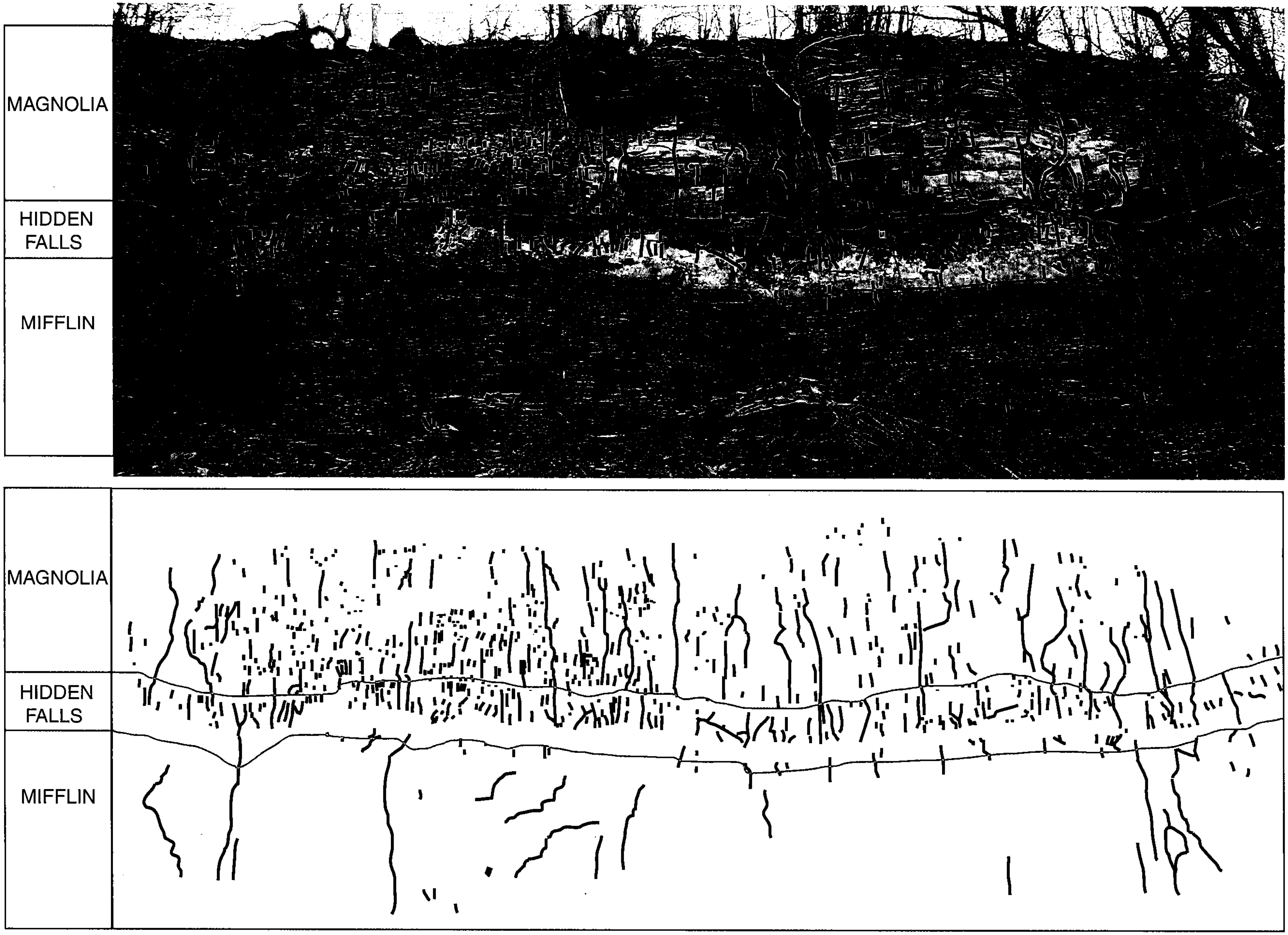
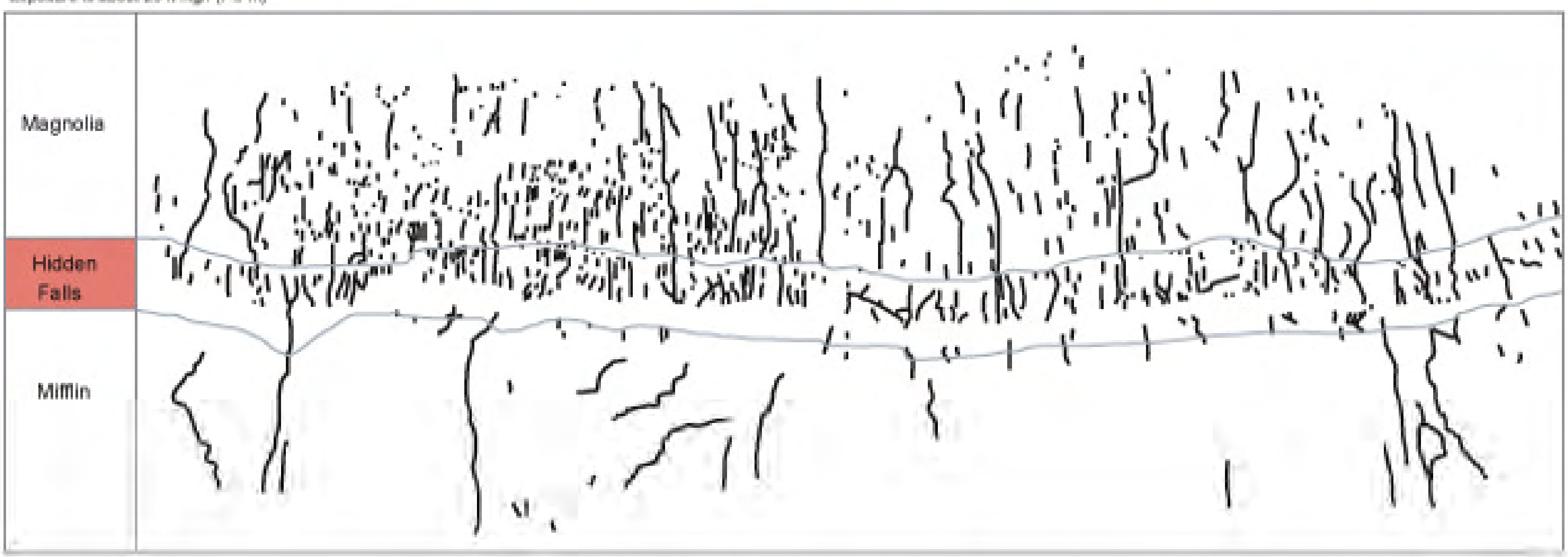


Figure 7. Vertical fracture map of the Mendota locality with and without the outcrop photograph. Vertical fractures are shown as black lines. The gray lines represent the upper and lower contacts of the Hidden Falls and correspond to the vertical-fracture termination horizons. Each member of the Platteville Formation has a distinct style of vertical fracture spacing and density and act as mechanical units with vertical fractures terminating at member contacts specifically near the top and bottom of the Hidden Falls Member. Exposure is ~7.6 m (25 ft) high.

VERTICAL FRACTURE CHARACTERIZATION

Exposure is about 25 ft high (7.5 m)



Individual members have characteristic fracture patterns, and preferential termination corresponds to member contacts

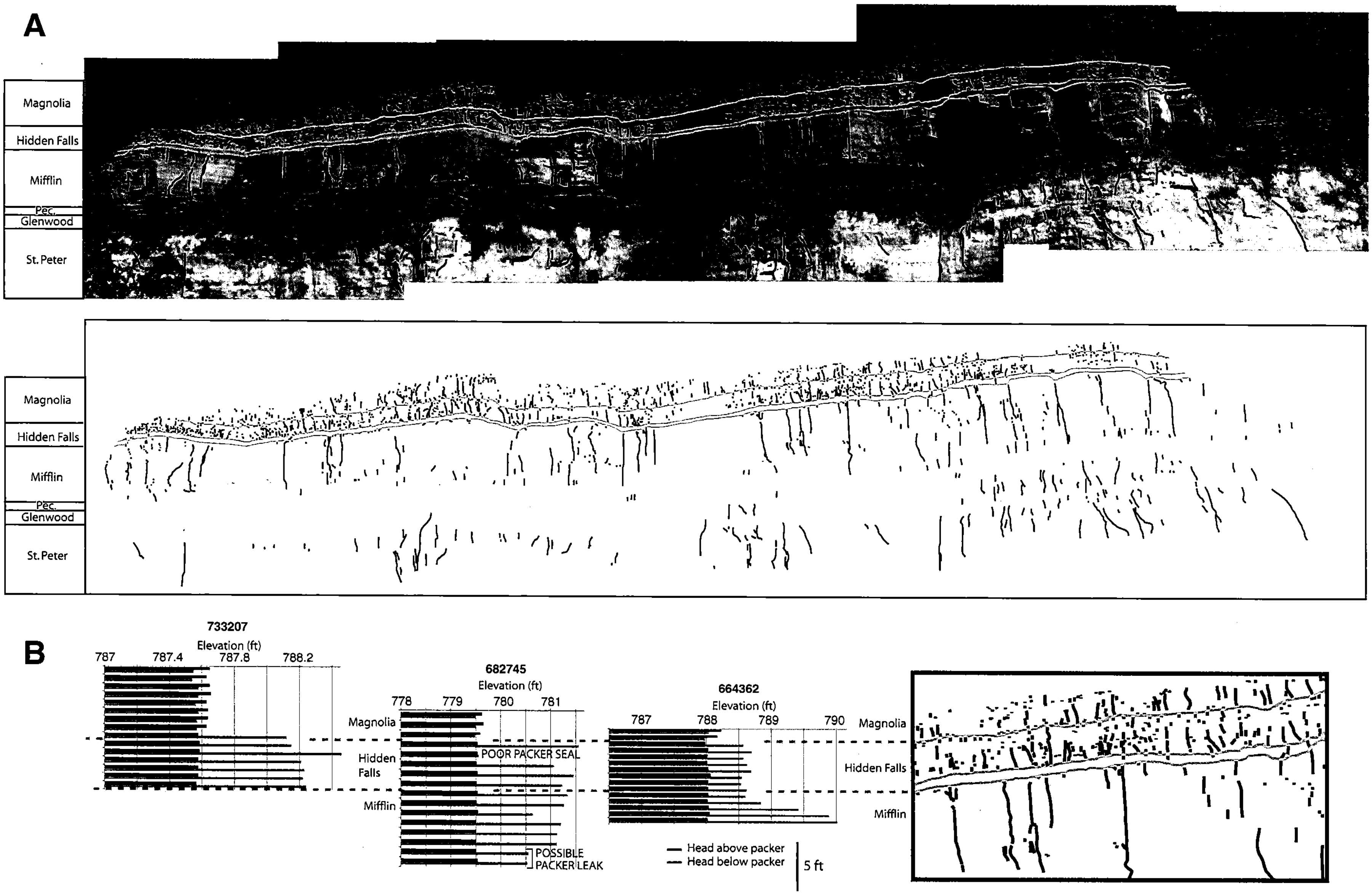


Figure 8. (A) Vertical fracture map of the Shepard Road locality with and without the outcrop photograph. Vertical black lines represent the vertical fractures. Gray lines depict the vertical-fracture termination horizons near the top and bottom of the Hidden Falls Member similar to Figure 7. Exposure is ~14 m (45 ft) high. (B) Vertical differences in static head conditions within the Platteville Formation from three monitor wells on the campus of the University of Minnesota. These preliminary packer-test results suggest poor vertical hydraulic connectivity between the Magnolia Member and underlying members, indicated by the abrupt change in head differences above and below the packer across the Magnolia–Hidden Falls contact strata. This contact corresponds to the point at which vertical fractures preferentially terminate in outcrop.

Platteville exposure. UTM coordinates of the exposure: 484,473 E/4,972,271 N. TRS location: T. 28 N, R. 23 W, sec. 18, SE, NE.

Discussion: This outcrop is one of the most accessible outcrops of the Hidden Falls and Magnolia contact strata. The laterally continuous recessive bedding plane (Figs. 9A and 9B) corresponds to the position of the bedding plane conduit recognized in many boreholes and at springs across the TCM area. As we've discussed at previous stops, it is also a mechanical interface, where vertical fractures preferentially terminate in outcrop. This stop is an opportunity to get an up-close look at this hydraulically important interval of strata again, fully describe its features, and briefly discuss modes of origin of bedding plane conduits.

As mentioned at Stop 1, the contact between the Hidden Falls and Magnolia is transitional compared with the other member contacts in the Platteville Formation. The top of the Hidden Falls is placed at a regionally traceable burrowed surface separating a dolomitic mudstone below from a fossiliferous argillaceous limestone above. The lowermost half-meter of the Magnolia Member consists of lenticular, centimeter-scale interbeds of fossiliferous, burrowed, and argillaceous limestone that contrasts to the cleaner, dolomitic mudstone beds with thin fossiliferous lenses characteristic of the Magnolia higher in the section. The thickness of this transitional interval ranges from ~0.15 to 0.4 m (0.5 to 1.5 ft). At this stop the recessive, weathered, bedding plane lies at the base of this transitional interval. Other exposures around the TCM area can be seen where this recessive bedding plane is either within the middle or at the top of this transitional interval, suggesting that the conduit developed at this interval is not along a single, precise stratigraphic position at centimeter scale everywhere in the TCM area.

At this stop the recessively weathered, transitional interval contains two limestone beds (Fig. 9B). The lower bed is a fossiliferous limestone ~2–5 cm thick, and the upper bed is a burrowed mudstone ~5 cm thick. Partings between these beds at this and other outcrops are filled with a brownish-orange to gray clay. Engineering borings elsewhere in the TCM area describe a similar clay-rich material at this stratigraphic position, indicating that it is present in the subsurface away from the bluff edge. Although referred to as a bentonite by some previous workers, a sample of this material from Shadow Falls (Stop 1) was analyzed by Mossler (1985), who reported that the clay was illite. A water-washed and sieved sample collected from Shadow Falls contained very fine sand- to silt-sized calcareous crystals that may represent carbonate residuum from dissolution. Furthermore, some of the fine-grained unconsolidated material along these partings is laterally transitional with indurated limestone lenses, also consistent with production of the fine material via solution weathering.

Our tentative interpretation is that the fine-grained material filling bed partings at this and other exposures is largely the relatively insoluble product of solution weathering, perhaps including both material derived from in situ weathering as well as material transported in suspension via turbulent conduit flow. Understanding the origin and timing of emplacement of this material may help us further understand the development of this bedding plane conduit system. Our working hypothesis is that the

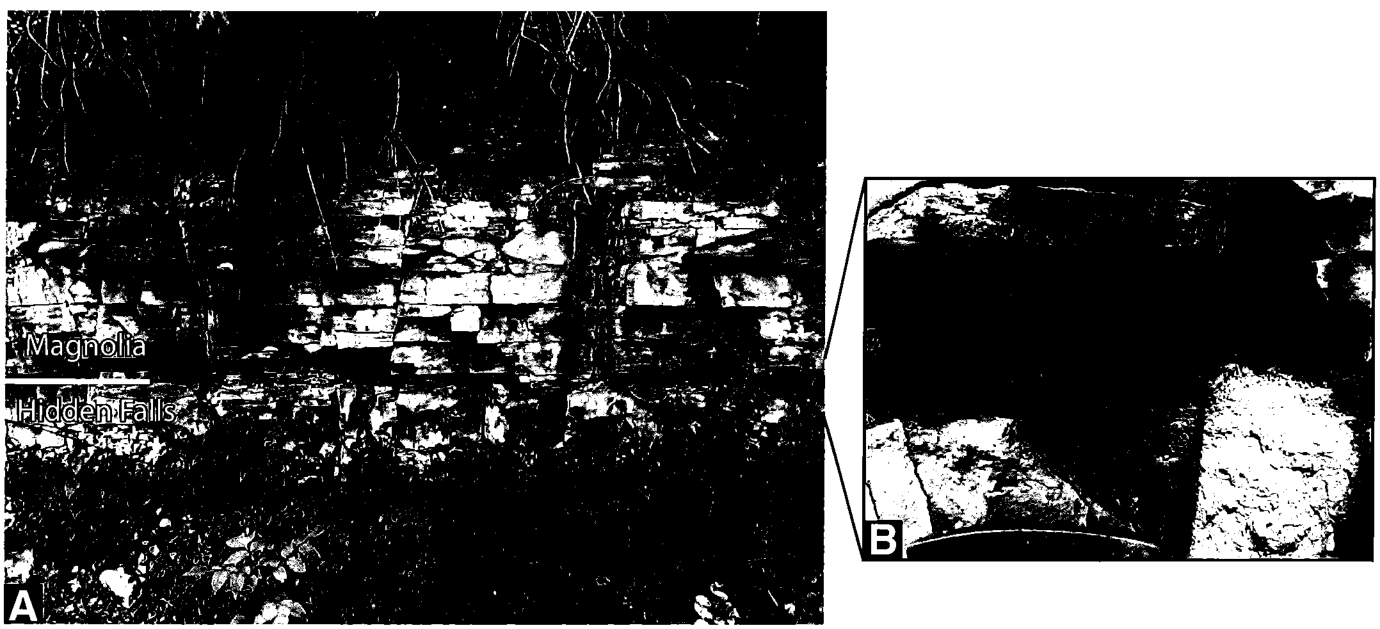


Figure 9. (A) Photograph of the Magnolia and Hidden Falls contact on the Fort Snelling bike trail, showing termination of vertical fractures at the top of the Hidden Falls Member. Exposure is ~3 m (10 ft) high. (B) Close-up view, showing the bedding plane interval that corresponds to the conduit recognized in many boreholes and at springs across the Twin Cities Metropolitan area and the clay-rich material that is filling the bed partings. Head of hammer for scale is ~18 cm long.

incipient development of the bedding parallel conduit system in this discrete interval may be the result of very early, preferential dissolution of the relatively coarse limestone beds in an otherwise largely finer grained and dolomitic Platteville Formation above and below.

Stop 7. Camp Coldwater Spring: Dye Tracing in the Platteville

Location: From Stop 6, continue south down the Minnehaha Park Road. Follow signs for "Camp Cold Water Spring." The spring is situated on the grounds of the former U.S. Bureau of Mines, directly northeast of the intersection of Highways 55 and 62. UTM coordinates of the spring: 484,490E, 4,971,800N. TRS location: T. 28 N, R. 23 W, sec. 20, SW, NE.

Discussion: Camp Coldwater Spring emerges from the west side of a small masonry pond and adjoining tower (Fig. 10). The spring itself is a cultural and historical landmark. It figures into the Dakotah creation story and is still considered a sacred spot by Native Americans. It also served as the water source and campsite for the men constructing Fort Snelling in 1820; because it was a notable supply of cold water, it was given its name. The spring continued serving as the water supply of the fort until the start of the twentieth century, using the structure in front of the spring for that function.

Camp Coldwater Spring emerges from an outcrop of the Platteville; monitoring of the spring's discharge in recent years has found it fluctuating from 50 to 125 gpm, with flows typically ranging from 70 to 90 gpm. This makes Camp Coldwater Spring the largest remaining spring in Minneapolis. Because of concern for the effects of the construction of State Highway 55 would have on Camp Coldwater Spring and other springs along the Minnehaha Creek gorge in Minnehaha Park, several hydrogeologic studies were carried out from Minnehaha Park to Camp Coldwater Spring.

Figure 10. Photograph of Camp Coldwater Spring, discharging near the base of the tower at the Hidden Falls and Magnolia contact.

The spring discharge emerges from the convergence of several vertical joints and a bedding plane fracture at the Hidden Falls–Magnolia contact (Fig. 11). A seismic study by Bison Service Co. (2000a, 2000b) found that the two joints intersecting at the spring had orientations of N 36° W and N 54° E. The former joint was described as a more prominent feature and extended to the northwest to the portion of Minnehaha Park west of State Highway 55.

Several pumping-test investigations have been carried out in this portion of Minnehaha Park. Liesch (1973) carried out several pumping tests using dozens of wells installed in the overburden and Platteville. The estimated transmissivities from these tests are summarized in Table 1 and range from 1400 to 1,600,000 gallons per day per foot (gpd/ft). Another pumping test was conducted in 2000 and analyzed by Kelton Barr Consulting (2000). The test revealed a drawdown distribution distended in two principal directions that inferred the location and influence of two hydraulically significant joints, trending approximately N 45° W and N 50° E; these orientations closely correspond to the two major joint orientations measured by Olsen (1999, personal commun.) on nearby outcrops along the Mississippi River and Minnehaha Creek bluffs. The former joint also was in very close proximity to the wells that yielded the three transmissivity values >500,000 gpd/ft in Liesch (1973). A quarter-mile southeast of the location of the pumping tests, the extrapolation of the former joint passed very closely by the east side of an excavation into the Platteville for a grit chamber as part of the Highway 55 construction. Groundwater flooded into the east side of the excavation via a bedding plane fracture at the Hidden Falls–Magnolia contact; the excavation was dewatered at a rate of 500 gpm for several months (Kelton Barr Consulting, 2000).

Additional geophysical investigation using ground-penetrating radar was carried out in Minnehaha Park upland directly south of Minnehaha Falls. The results found a network of northeast- and northwest-trending joints. The locations and intersections of these joints corresponded closely with the occurrence of minor springs along the bluff between Minnehaha Falls and Camp Coldwater Spring.

Dye tracing studies were carried out in 2001 in the intersection area of State Highways 55 and 62 west of Camp Coldwater Spring (Fig. 1). Eosin Y fluorescent dye was added to a trench excavated to the Platteville surface 125 m west of Camp Coldwater Spring. The dye began to arrive at the spring in <1.5 h, migrating at an apparent velocity of 2 km/d (1.24 mi/d). A subsequent dye-trace test was carried out at a dewatering sump at the center of the present-day intersection, ~290 m (950 ft) west-southwest of the spring. Within hours of a court-ordered halt to pumping, fluorescein dye was added to the sump. The dye was detected at Camp Coldwater Spring 16 d later. The travel path was more complex for this test, as the sump was excavated into the glaciofluvial sediments filling a buried east-west valley eroded through the Platteville a short distance south of the spring. The apparent

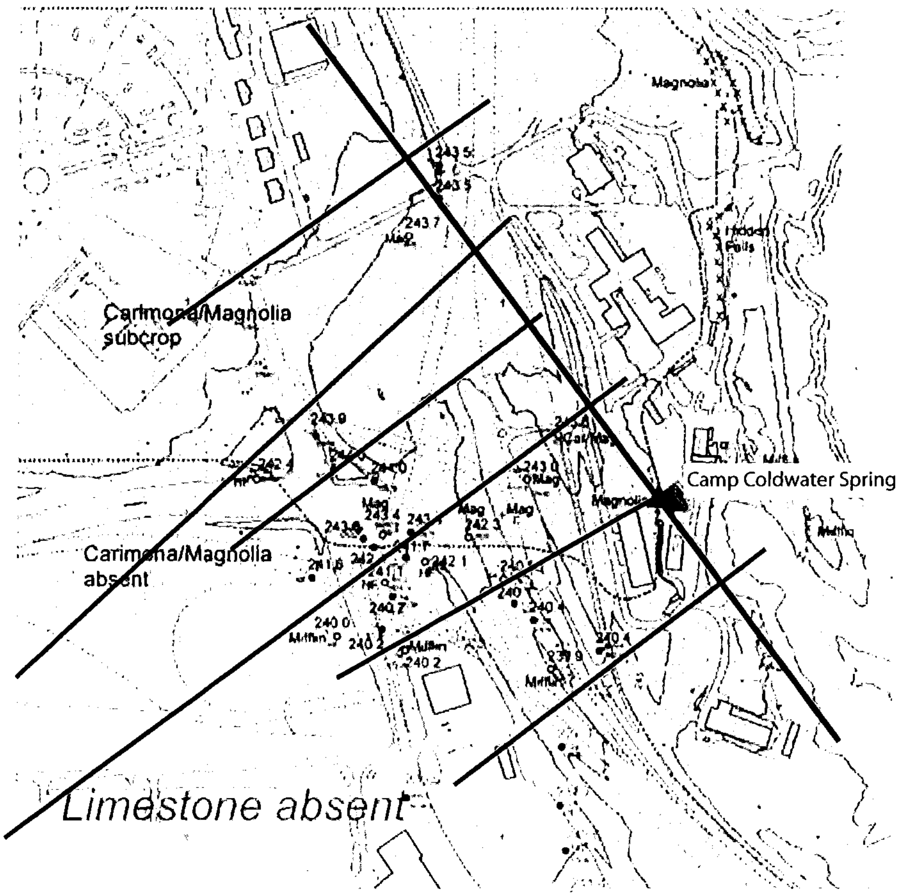


Figure 11. Geology of the Camp Coldwater Spring vicinity, showing the location and orientation of vertical joints (black lines) that converge toward the emergence of the spring. The dark-gray background color represents a full Platteville subcrop; the medium-gray color represents a partial Platteville subcrop where only the Hidden Falls, Mifflin, and Pecatonica Members are present; and the lightest gray color is where all the Platteville is absent. Compiled from Sunderman and Kurtz (2000) and Bison Service Company (2000a, 2000b).

TABLE 1. SUMMARY OF TRANSMISSIVITY AND STORAGE COEFFICIENT VALUES FROM PUMPING TESTS NEAR MINNEHAHA FALLS PARK CARRIED OUT BY LIESCH (1973) AND KELTON BARR CONSULTING (2000)

Well No.	Pumping Rate (gpm)	Test Duration (hr)	Maximum Drawdown (ft)	Transmissivity (T) (gpd/ft)	Storage Coefficient (S)	Parameters calculated from:
T1d-wa	90	48	17.5	40,000		Recovery in pumping well
T1d-wa	90	48	17.5	36,554	2.60E-03	Time-drawdown curve at t1f-Pa (6")
T1d-wa	90	48	17.5	530,000	8.80E-03	Distance-drawdown curve from T9-wa to T10-wa
T2d-wa	8	2	4.5	1,400		Time-drawdown curve at pumping well
T2d-wa	8	2	4.5	3,840	4.00E-05	Time-drawdown curve at t2b-Pa (6")
T2d-wa	8	2	4.5	5,000	1.20E-04	Distance-drawdown curve
T3d-wa	30	24	7.5	5,200	4.20E-05	Time-drawdown curve at t3b-Pa (6")
T4b-Pa (6")	8	1	4.9	4,000	4.00E-03	Time-drawdown durve at t4d-wa
T4d-wa	8	1	1.9	4,200	4.00E-03	Time-drawdown curve at t4b-Pa (6")
T5b-Pa (6")	8	1.5	0.5	7,000	1.80E-05	Time-drawdown curve at t4b-Pa (6")
T6-wa	8	1	2.9	5,700		Time-drawdown curve at pumping well
T7-wa	10	1.25	3.7	2,900		Time-drawdown curve at pumping well
T9-wa	60	2	0.14	700,000		Time-drawdown curve at pumping well
T10-wa	60	1	0.07	1,600,000	9.00E-03	Distance-drawdown curve at observation wells
T2d-Wb	10	3	2.73	6,800	1.60E-01	Drawdown at T2C-Pb
T4b-Wb	30	1	2.15	17,600	5.80E-02	Drawdown at pumping well t4b-Wb
T4b-Wb	30	1	2.15	26,000		
			Average =	176,247	2.24E-02	
			Median =	6,800	4.00E-03	
			Mean =	16,881	1.53E-03	

flow velocity of 19 m/d (63 ft/d) is a combination of flow through the alluvial porous media and the Platteville fractures (Alexander et al., 2001).

The karstic and fractured flow patterns within the Platteville in the vicinity of Minnehaha Park and Camp Coldwater Spring are not thought to have been significantly altered and thus still reflect those flow patterns established prior to the creation of the Mississippi River and Minnehaha Creek gorges, created 12,700–10,000 yr ago (Wright, 1972). These investigations reveal a predominance of flow generally through the Hidden Falls–Magnolia contact, augmented and redistributed by hydraulically significant joints intersecting that contact.

Stop 8. Bird Dropping Spring: Hydrocarbon Contamination in the Platteville

Location: Parking UTM coordinates: 479,970 E/4,980,608 N. TRS location: T. 29 N, R. 24 W, sec. 23, SW, SE. Walk down bike path southeast toward the spring. Spring UTM coordinates: 480,340 E/4,980,559 N. TRS location: T. 29 N, R. 24 W, sec. 23, SE, SE.

Directions: From Stop 7 take a right on to Hiawatha Avenue (Highway 55) heading north. Keep right at the fork, follow signs for 3rd Street and merge onto 3rd Street S. Turn right onto Chicago Avenue and left onto S 2nd Street. Take a right on Portland Avenue S and veer right under the Stone Arch Bridge to parking area.

Discussion: Bird Dropping Spring (Fig. 12) emanates from two closely spaced vertical fractures in the lower Hidden Falls and uppermost Mifflin that terminate in the middle part of the Mifflin Member. This is the only spring we observed in the TCM area that discharges at this stratigraphic position, and we believe it represents an example of the outcrop-edge, step-down effect. We hypothesize that groundwater in the nearby subsurface is primarily traveling along the Hidden Falls and Magnolia contact, based on nearby borehole flowmeter and other hydraulic tests. Groundwater steps downward as the bluff edge is approached, where vertical fractures are more densely developed and better connected vertically across the Magnolia, Hidden Falls, and uppermost Mifflin Members.

This spring is called *Bird Dropping Spring* in reference to the white, cottage-cheese-like, microbial masses that adhere to the Platteville Formation within the spring discharge. These masses appear here and at other sites where the groundwater is contaminated with hydrocarbons. A strong odor of hydrocarbons can be detected at this spring. The contamination in the groundwater at this location is from obsolete gasoline storage sites south of the site. Shallowly buried and fractured carbonate rock in an urban setting, such as the Platteville Formation, is highly susceptible to contamination, as pollutants can travel quickly from the surface and into a network of bedding plane and vertical fractures. Better understanding of the development of these fracture pathways and groundwater flow paths in the Platteville limestone will aid in the implementation of groundwater remediation efforts in the TCM area and in other parts of the Upper Midwest with similar geologic settings.

Stop 9. Andersen Library: Platteville Hydrostratigraphy, Putting Everything Together

Location: This stop is at the entrance to the University of Minnesota Andersen Library underground archive building. UTM coordinates: 480,895 E/4,979,991 N. TRS location: T. 29 N, R. 24 W, sec. 25, SE, NW.

Directions: From Stop 8, travel back toward Portland Avenue and take a left onto W River Parkway. Take a right onto 22nd Avenue S and a quick left into the MLAC parking area.

Discussion: Underground excavations in the TCM area are especially useful for the rare three-dimensional perspectives they provide for fractures and groundwater flow when combined with cores and outcrops. At this stop, we will show and discuss information collected during construction of an underground library archive building for the University of Minnesota, the MLAC. Outside the entrance to this facility we will highlight insights gained during excavation and remediation of contaminated

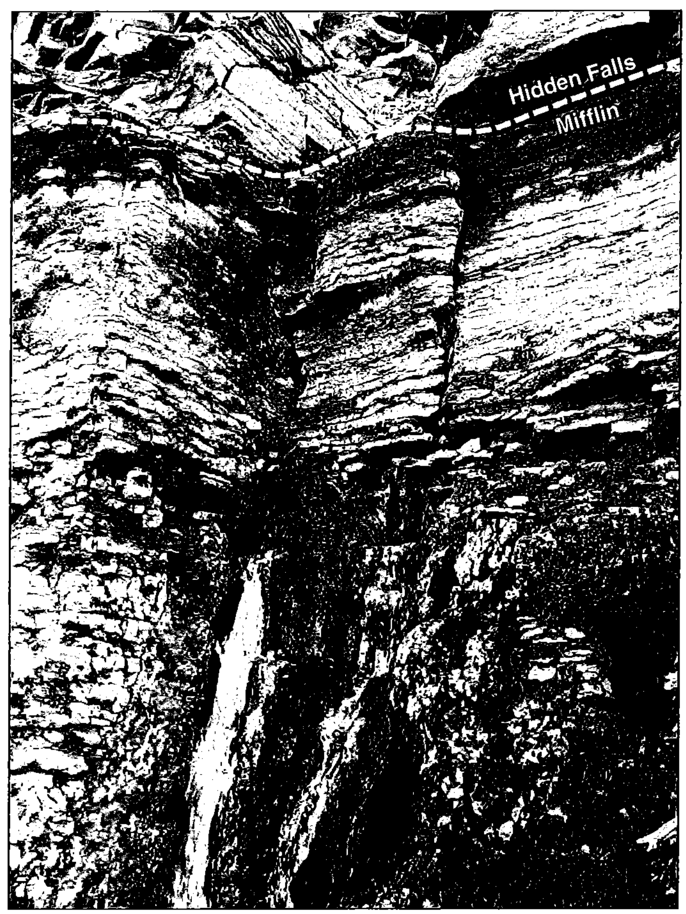


Figure 12. Photograph of Bird Dropping Spring discharging at the base of two vertical fractures in the upper Mifflin Member. Bluff exposure in the photograph is ~2 m (7 ft) high.

leakage through the bottom of the Platteville Formation, which serves as the rock ceiling for this facility. We will also provide a summary of the field trip in the context of our current conceptual model of Platteville hydrostratigraphy (Fig. 3).

Excavation for the underground part of the MLAC began in 1997 and included removal of the upper ~6 m (20 ft) of the St. Peter Sandstone. When the overlying Glenwood shale was subsequently stripped, immediate and significant leakage of groundwater contaminated with coal tar derivatives occurred through a network of vertical joints exposed at the bottom of the Platteville Formation. Subsequent remedial work included installation of a pan system to capture water from leaking joints, which are restricted to the ~80 m of the excavation closest to the eroded edge of the Platteville at the river bluff (Fig. 13). In 2002, a horizontal pump-out well was installed along the Hidden Falls–Magnolia contact strata, and the system reduced leakage into the panning system by ~65% (Peer Environmental and Engineering Resources, Inc., 2003). Continued maintenance of the system includes periodic removal of microbial masses from the pan and well system that are similar in appearance to those at Bird Dropping Spring.

Combined data from MLAC pre-excavation (CNA, 1997) and remediation-related (Peer Environmental and Engineering Resources, Inc., 1999, 2003) reports result in a hydrogeologic characterization consistent with many other metro sites (Fig. 3). Surface excavations penetrating about a meter into bedrock, vertical shafts, cores, and other bedrock borings indicate that the secondary porosity in the Magnolia Member in subsurface conditions is similar to its appearance at the outcrops at Stops 3 and 4. As uppermost bedrock, it is highly fractured, with abundant and closely spaced vertical fractures and a number of bedding plane fractures, resulting in a blocky fracture pattern. As at many other metro subsurface sites, it contains a body of water that is perched on top of the Hidden Falls Member. A large number of discrete interval packer, slug, and larger scale aquifer tests of the Magnolia Member show a range in horizontal hydraulic conduc-

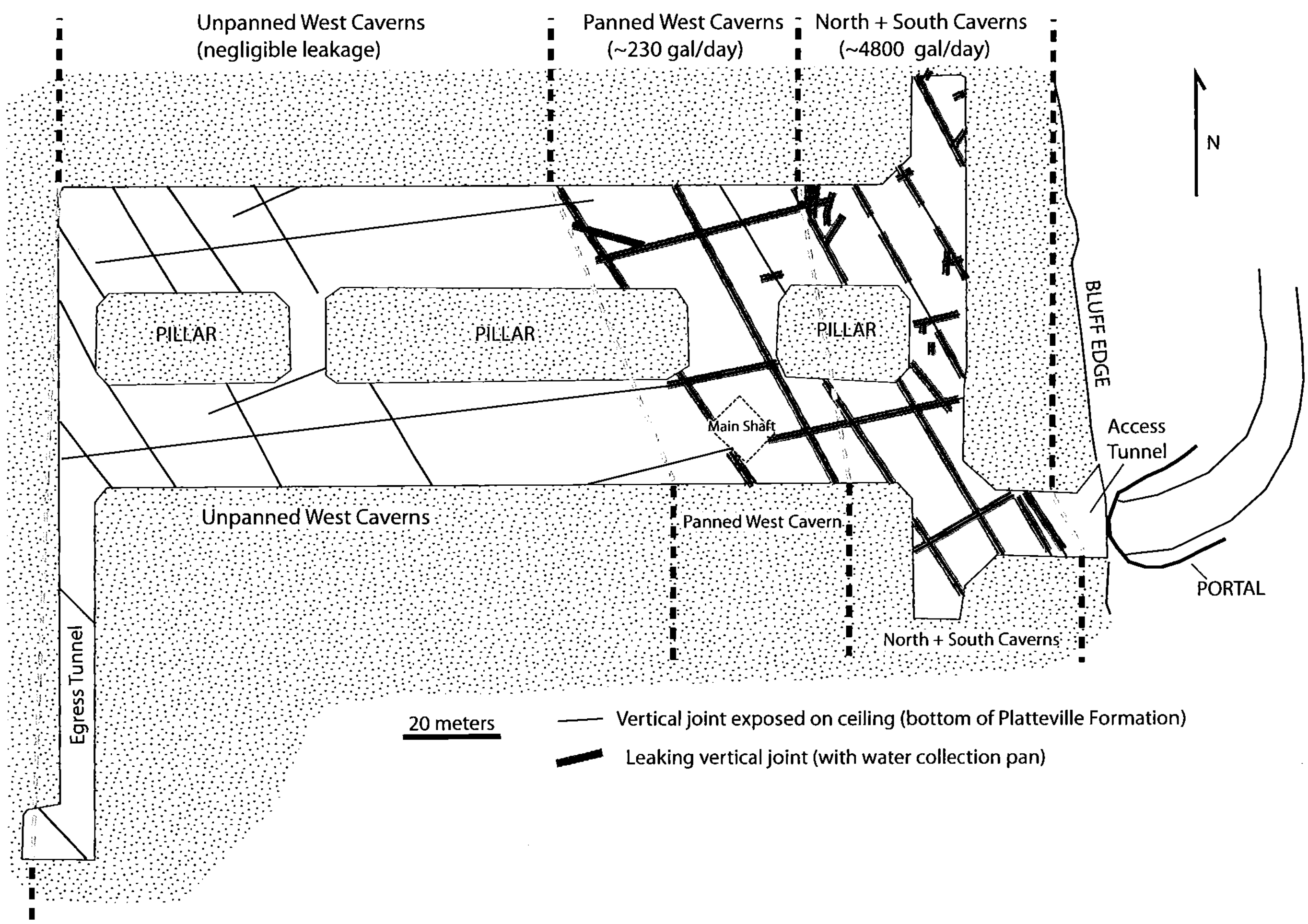


Figure 13. Map of excavation at the Minnesota Library Access Center underground library storage facility at the University of Minnesota, highlighting mapped vertical joints on the ceiling of the excavation, which is the bottom of the Platteville Formation. Monitoring of flow collected from pans installed beneath leaking joints provides quantification of leakage rates. The site lies beneath an ~2.1 m (7 ft) thick body of water perched on top of the Hidden Falls Member. Modified from Peer Environmental and Engineering Resources, Inc. (2001).

tivity that varies from a few feet per day to hundreds of feet per day. A bulk average horizontal hydraulic conductivity for individual sites is typically calculated at several tens to as much as ~200 ft/d. Multi-well aquifer tests, dye traces, and mapped contamination plumes across the TCM area indicate that fractures are typically well connected vertically. Vertical hydraulic conductivity for the Magnolia Member at MLAC was calculated to be as high as 4 ft/d, although lower values were obtained with the same aquifer test data using other methods of analysis (Peer Environmental and Engineering Resources, Inc., 1999).

The lowermost ~10–50 cm of the Magnolia, the "transitional" Hidden Falls–Magnolia contact strata described at Stop 6, is especially conductive in a horizontal direction, containing a discrete bedding-plane fracture network with hydraulic conductivity measured as high as tens of thousands of feet per day in individual boreholes (Fig. 6). Borehole geophysical logs (including EM flowmeter logs), core, and underground excavation data collected near the University of Minnesota and at other TCM sites, tens to hundreds of meters away from bluff and subcrop edges, demonstrate that this discrete interval of bedding plane conduits at the Hidden Falls–Magnolia contact is widespread across the subsurface extent of the Platteville. Hydraulic properties of the Magnolia–Hidden Falls transition interval in a vertical direction are poorly understood, but limited data indicate that they may be greatly variable. At MLAC and other sites this transitional interval has been shown to be vertically well connected to the heavily fractured Magnolia Member higher in the section, serving as a lowermost "water main" that collects and transports horizontally large volumes of water recharged vertically through uppermost bedrock. However, in a setting more deeply buried by younger bedrock, flowmeter logging has revealed head differentials across this thin transitional interval driving ambient borehole flow, an indication that discrete intervals within the lowermost Magnolia at least locally may be resistant to through-going vertical fractures and therefore serving as aquitards.

The Hidden Falls, Mifflin, and Pecatonica Members typically have markedly lower horizontal hydraulic conductivity than the Magnolia Member. Hydraulic conductivity values from packer tests typically range from 10^{-1} to a few feet per day (e.g., CNA, 1997). Packed intervals commonly are unable to produce water at a sustained rate above a minimum pumping threshold. Values as high as a few tens of feet per day are relatively uncommon and likely indicate intersection or proximity to bedding plane fractures or vertical joints (e.g., Barr Engineering, 1987). In a vertical sense, parts of these Platteville members (possibly along with the lowermost Magnolia transitional strata, described above) serve as aquitards. Preferential termination of vertical fractures, as described at earlier stops, along with a systematic lateral change in fracture apertures and likely connectivity, appear to determine the stratigraphic position and relative integrity of these aquitards. Leakage through the ceiling of the excavation at MLAC provides some insight into the relative bulk vertical conductivity of the combined Hidden Falls, Mifflin, and Pecatonica Members (Fig. 13). Within ~80 m of the bluff edge, relatively high leakage rates (total of ~5000 gpd; Peer Environmental and Engineering Resources, Inc., 2001, 2003) into the panning system indicate a vertical hydraulic conductivity varying from 10^{-1} to 10^{-3} ft/d across individual parts of the ceiling. Beyond ~80 m from the bluff edge the ceiling is not panned, because leakage is negligible. Using a total leakage for the unpanned area of <10 gpd (Steve Jansen, Peer Engineering, 2011, personal commun.) vertical hydraulic conductivity is $<10^{-4}$ ft/d. The decreasing hydraulic conductivity deeper into the excavation reflects diminishing aperture width, and likely connectivity and trace length of vertical fractures with increasing distance from the bluff edge and subcrop surface.

Identification of discrete intervals that might serve as key aquitards within the combined Hidden Falls, Mifflin, and Pecatonica Members is an ongoing focus of our research. Hydraulic data compiled thus far suggest that the Hidden Falls Member plays a key role. Heads above and below the Hidden Falls are known to differ by as much as 3 m (10 ft) on the basis of nested well measurements (Braun Intertec Corporation, 2011), and our packer-derived head measurements also show abrupt head changes across the Magnolia–Hidden Falls contact (Fig. 8B). Perched water on top of the Hidden Falls, recognized at a number of subsurface sites and expressed also by springs, likewise suggests significant vertical resistance across the member. Collectively, the mechanical stratigraphy (Stops 3 and 4) and hydraulic data support a model whereby compartmentalization of vertical fractures from the lowermost Magnolia to the upper Mifflin leads to Hidden Falls and directly adjacent strata containing one or more key aquitards. The integrity of these discrete aquitards likely increases with increasing distance from outcrop or subcrop edges. Intact, unfractured cores of the Hidden Falls indicate that the pervasive, closely spaced but relatively short trace-length curvilinear to vertical fractures characteristic of outcrops are not present in nearly the same abundance in the deeper subsurface. This provides some support for our spring "step-down" hypothesis, whereby water approaching the bluff edge steps down to the next lowest mechanical interface at which joints preferentially terminate.

The combined information from MLAC, other subsurface sites, and our outcrop observations supports our preliminary conceptual model of the Platteville as a hybrid hydrogeologic unit, with some parts acting as aquifers and some as aquitards. Like other hybrid units identified in the Paleozoic bedrock of this area, even though matrix permeability is very low, secondary pore networks accommodate moderate to very high horizontal hydraulic conductivity sufficient to yield economic quantities of water to wells, and to supply springs with flow rates >10 gpm. Dye tracing, pump tests, and secondary pore observations demonstrate that the Platteville is consistent with the definition of a karstic aquifer that includes fast-flow conduits. Data from the same collection of sites also support the traditional classification of the Platteville Formation as a *confining unit,* when considered from a vertical perspective, with discrete intervals such as the upper and lowermost Hidden Falls Member serving as key, relatively high integrity aquitards. Relatively thin stratigraphic intervals of 2 m or less appear to contain both the highest hydraulic conductivity bedding-plane conduits as well as the key aquitards. Despite this complexity, our ongoing work thus far appears to show a strong connection between stratigraphic units and the development of both horizontal and vertical secondary pore networks, and thus the potential for a strong degree of predictability in the flow path geometries.

ACKNOWLEDGMENTS

Our work in the Twin Cities Metropolitan area has been supported by the Metropolitan Council. Special thanks to Greg Brick for sharing his years of experience on Platteville springs in the area and Steve Jansen from Peer Engineering for his insights into construction of the Minnesota Library Access Center. We also thank Janet Dalgleish with the University of Minnesota Department of Environmental Health and Safety for helping us access water wells and Pat Mosites with the Metropolitan Airports Commission.

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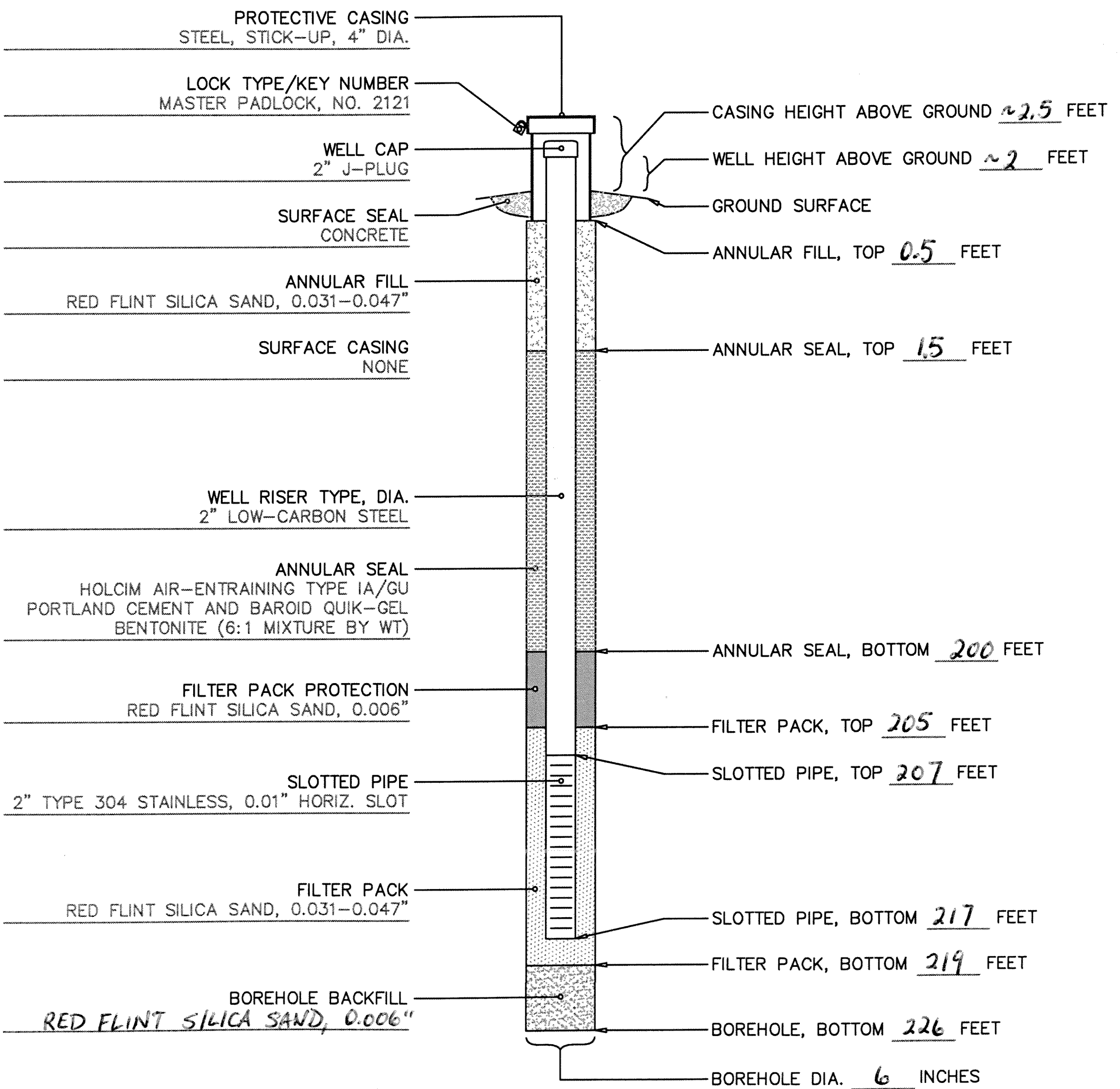
Appendix E

Well Logs Referenced in this Report

Well W414

WELL CONSTRUCTION DIAGRAM	WELL DESIGNATION: SLP01
CLIENT U.S. EPA ENVIRONMENTAL RESPONSE TEAM	CONTRACT NAME RESPONSE ENGINEERING AND ANALYTICAL CONTRACT (REAC)
PROJECT NAME HIGHWAY 7 & WOODDALE AVENUE SITE	CONTRACT NO. EP-C-04-032
PROJECT CITY, STATE ST. LOUIS PARK, MN	CONTRACTOR LOCKHEED MARTIN
PROJECT NO. EAC401-EAC00289	INSPECTOR CHRISTOPHER SKLANEY
DRILLING ORGANIZATION BOART LONGYEAR ENGINEERING & INFRASTRUCTURE	OTHER DESIGNATION (MDH UNIQUE DESIGNATION) 763378
DRILLER NAME DAN O'MARA	WELL LOCATION 507488.691 E, 152536.613 N
DRILLING RIG/METHOD ROTARY SONIC	WELL ELEVATION 921.29 ft AMSL
INSTALLATION START DATE 05/19/2008 — INSTALLATION COMPLETION DATE 05/20/2008	COORDINATE SYSTEM HENNEPIN CO., MN, COUNTY COORD SYS (NAD83) ADJUSTED

NOTE: ADDED SAND IN SPACE BETWEEN PROTECTIVE CASING AND WELL WITH SAND TO PROMOTE DRAINAGE



NOT TO SCALE

POSITIVE DEPTHS DOWNHOLE FROM GROUND SURFACE
BOREHOLE DIAMETERS IN NOMINAL TERMS

I:\GEO\289 HIGHWAY 7 & WOODDALE AVE\LOGS\...

Well W415

WELL CONSTRUCTION DIAGRAM		WELL DESIGNATION: SLP02
CLIENT U.S. EPA ENVIRONMENTAL RESPONSE TEAM		CONTRACT NAME RESPONSE ENGINEERING AND ANALYTICAL CONTRACT (REAC)
PROJECT NAME HIGHWAY 7 & WOODDALE AVENUE SITE		CONTRACT NO. EP-C-04-032
PROJECT CITY, STATE ST. LOUIS PARK, MN		CONTRACTOR LOCKHEED MARTIN
PROJECT NO. EAC401-EAC00289		INSPECTOR CHRISTOPHER SKLANEY
DRILLING ORGANIZATION BOART LONGYEAR ENGINEERING & INFRASTRUCTURE		OTHER DESIGNATION (MDH UNIQUE DESIGNATION) 763377
DRILLER NAME DAN O'MARA		WELL LOCATION 507497.754E, 152537.193N
DRILLING RIG/METHOD ROTARY SONIC		WELL ELEVATION 920.16 ft AMSL
INSTALLATION START DATE 05/19/2008	INSTALLATION COMPLETION DATE 05/20/2008	COORDINATE SYSTEM HENNEPIN CO., MN, COUNTY COORD SYS (NAD83) ADJUSTED

NOTE: ADDED SAND IN SPACE BETWEEN PROTECTIVE CASING AND WELL WITH SAND TO PROMOTE DRAINAGE

PROTECTIVE CASING
STEEL, STICK-UP, 4" DIA.

LOCK TYPE/KEY NUMBER
MASTER PADLOCK, NO. 2121

WELL CAP
2" J-PLUG

SURFACE SEAL
CONCRETE

ANNULAR FILL
RED FLINT SILICA SAND, 0.031-0.047"

SURFACE CASING
NONE

WELL RISER TYPE, DIA.
2" LOW-CARBON STEEL

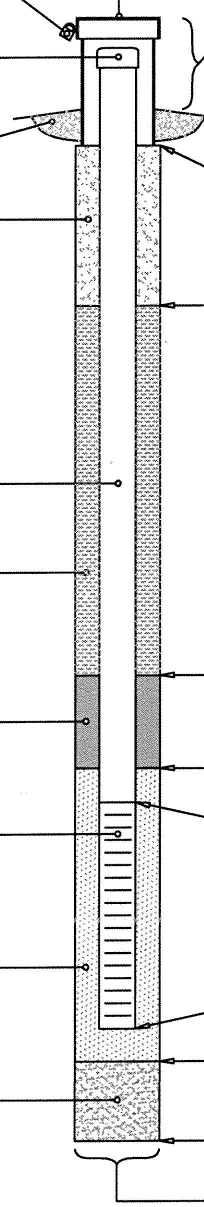
ANNULAR SEAL
HOLCIM AIR-ENTRAINING TYPE IA/GU
PORTLAND CEMENT AND BAROID QUIK-GEL
BENTONITE (6:1 MIXTURE BY WT)

FILTER PACK PROTECTION
RED FLINT SILICA SAND, 0.006"

SLOTTED PIPE
2" TYPE 304 STAINLESS, 0.01" HORIZ. SLOT

FILTER PACK
RED FLINT SILICA SAND, 0.031-0.047"

BOREHOLE BACKFILL
NONE



CASING HEIGHT ABOVE GROUND ~2.5 FEET

WELL HEIGHT ABOVE GROUND ~2 FEET

GROUND SURFACE

ANNULAR FILL, TOP 0.5 FEET

ANNULAR SEAL, TOP 1.5 FEET

ANNULAR SEAL, BOTTOM 88 FEET

FILTER PACK, TOP 93 FEET

SLOTTED PIPE, TOP 95 FEET

SLOTTED PIPE, BOTTOM 105 FEET

FILTER PACK, BOTTOM 105 FEET

BOREHOLE, BOTTOM 105 FEET

BOREHOLE DIA. 6 INCHES

NOT TO SCALE

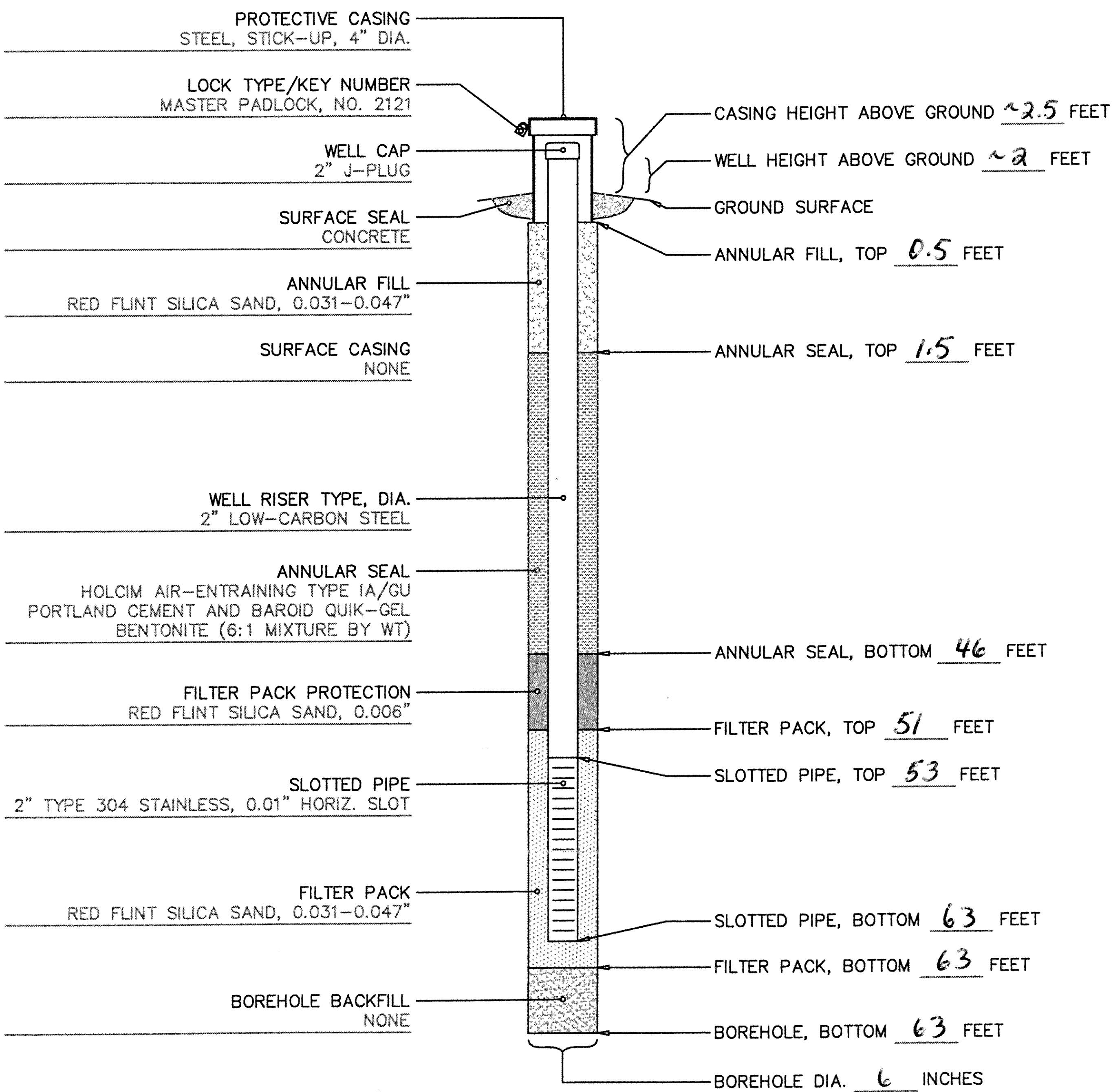
POSITIVE DEPTHS DOWNHOLE FROM GROUND SURFACE
BOREHOLE DIAMETERS IN NOMINAL TERMS

I:\GEO\289 HIGHWAY 7 & WOODDALE AVE\LOGS\...

Well W416

WELL CONSTRUCTION DIAGRAM	WELL DESIGNATION: SLP03
CLIENT U.S. EPA ENVIRONMENTAL RESPONSE TEAM	CONTRACT NAME RESPONSE ENGINEERING AND ANALYTICAL CONTRACT (REAC)
PROJECT NAME HIGHWAY 7 & WOODDALE AVENUE SITE	CONTRACT NO. EP-C-04-032
PROJECT CITY, STATE ST. LOUIS PARK, MN	CONTRACTOR LOCKHEED MARTIN
PROJECT NO. EAC401-EAC00289	INSPECTOR CHRISTOPHER SKLANEY
DRILLING ORGANIZATION BOART LONGYEAR ENGINEERING & INFRASTRUCTURE	OTHER DESIGNATION (MDH UNIQUE DESIGNATION) 763376
DRILLER NAME DAN O'MARA	WELL LOCATION 507492.681 E, 152545.098 N
DRILLING RIG/METHOD ROTARY SONIC	WELL ELEVATION 920.21 ft AMSL
INSTALLATION START DATE 05/19/2008 — INSTALLATION COMPLETION DATE 05/20/2008	COORDINATE SYSTEM HENNEPIN CO., MN, COUNTY COORD SYS (NAD83) ADJUSTED

NOTE: ADDED SAND IN SPACE BETWEEN PROTECTIVE CASING AND WELL WITH SAND TO PROMOTE DRAINAGE



POSITIVE DEPTHS DOWNHOLE FROM GROUND SURFACE
BOREHOLE DIAMETERS IN NOMINAL TERMS

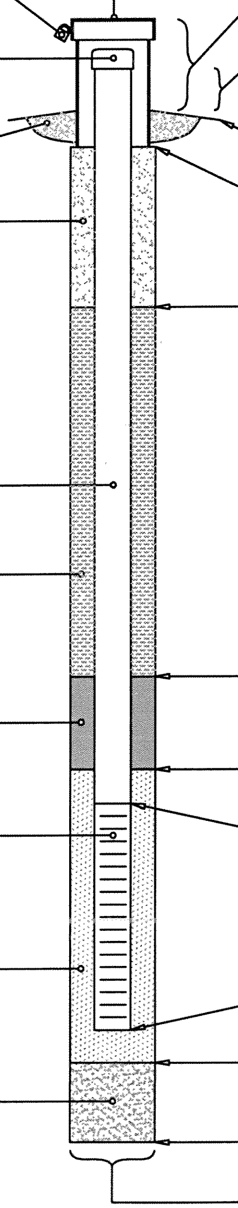
NOT TO SCALE

I:\GEO\289 HIGHWAY 7 & WOODDALE AVE\LOGS\...

Well W417

WELL CONSTRUCTION DIAGRAM		WELL DESIGNATION: SLP04
CLIENT U.S. EPA ENVIRONMENTAL RESPONSE TEAM		CONTRACT NAME RESPONSE ENGINEERING AND ANALYTICAL CONTRACT (REAC)
PROJECT NAME HIGHWAY 7 & WOODDALE AVENUE SITE		CONTRACT NO. EP-C-04-032
PROJECT CITY, STATE ST. LOUIS PARK, MN		CONTRACTOR LOCKHEED MARTIN
PROJECT NO. EAC401-EAC00289		INSPECTOR CHRISTOPHER SKLANEY
DRILLING ORGANIZATION BOART LONGYEAR ENGINEERING & INFRASTRUCTURE		OTHER DESIGNATION (MDH UNIQUE DESIGNATION) 763379
DRILLER NAME DAN O'MARA		WELL LOCATION 505865.243 E, 152662.575 N
DRILLING RIG/METHOD ROTARY SONIC		WELL ELEVATION 928.08 ft AMSL
INSTALLATION START DATE 05/19/2008	INSTALLATION COMPLETION DATE 05/20/2008	COORDINATE SYSTEM HENNEPIN CO., MN, COUNTY COORD SYS (NAD83) ADJUSTED

NOTE: ADDED SAND IN SPACE BETWEEN PROTECTIVE CASING AND WELL WITH SAND TO PROMOTE DRAINAGE



PROTECTIVE CASING
STEEL, STICK-UP, 4" DIA.

LOCK TYPE/KEY NUMBER
MASTER PADLOCK, NO. 2121

WELL CAP
2" J-PLUG

SURFACE SEAL
CONCRETE

ANNULAR FILL
RED FLINT SILICA SAND, 0.031-0.047"

SURFACE CASING
NONE

WELL RISER TYPE, DIA.
2" LOW-CARBON STEEL

ANNULAR SEAL
HOLCIM AIR-ENTRAINING TYPE IA/GU PORTLAND CEMENT AND BAROID QUIK-GEL BENTONITE (6:1 MIXTURE BY WT)

FILTER PACK PROTECTION
RED FLINT SILICA SAND, 0.006"

SLOTTED PIPE
2" TYPE 304 STAINLESS, 0.01" HORIZ. SLOT

FILTER PACK
RED FLINT SILICA SAND, 0.031-0.047"

BOREHOLE BACKFILL
NONE

CASING HEIGHT ABOVE GROUND ~3 FEET

WELL HEIGHT ABOVE GROUND ~2.5 FEET

GROUND SURFACE

ANNULAR FILL, TOP 0.5 FEET

ANNULAR SEAL, TOP 1.5 FEET

ANNULAR SEAL, BOTTOM 86 FEET

FILTER PACK, TOP 91 FEET

SLOTTED PIPE, TOP 93 FEET

SLOTTED PIPE, BOTTOM 103 FEET

FILTER PACK, BOTTOM 103 FEET

BOREHOLE, BOTTOM 106 FEET

BOREHOLE DIA. 6 INCHES

POSITIVE DEPTHS DOWNHOLE FROM GROUND SURFACE
BOREHOLE DIAMETERS IN NOMINAL TERMS

NOT TO SCALE

I:\GEO\289 HIGHWAY 7 & WOODDALE AVE\LOGS\...

Well W418

WELL CONSTRUCTION DIAGRAM	WELL DESIGNATION: SLP05
CLIENT U.S. EPA ENVIRONMENTAL RESPONSE TEAM	CONTRACT NAME RESPONSE ENGINEERING AND ANALYTICAL CONTRACT (REAC)
PROJECT NAME HIGHWAY 7 & WOODDALE AVENUE SITE	CONTRACT NO. EP-C-04-032
PROJECT CITY, STATE ST. LOUIS PARK, MN	CONTRACTOR LOCKHEED MARTIN
PROJECT NO. EAC401-EAC00289	INSPECTOR CHRISTOPHER SKLANEY
DRILLING ORGANIZATION BOART LONGYEAR ENGINEERING & INFRASTRUCTURE	OTHER DESIGNATION (MDH UNIQUE DESIGNATION)
DRILLER NAME DAN O'MARA	WELL LOCATION 505861.803 E, 152652.845 N
DRILLING RIG/METHOD ROTARY SONIC	WELL ELEVATION 928.21 ft AMSL
INSTALLATION START DATE 05/19/2008 · INSTALLATION COMPLETION DATE 05/20/2008	COORDINATE SYSTEM HENNEPIN CO., MN, COUNTY COORD SYS (NAD83) ADJUSTED

NOTE: ADDED SAND IN SPACE BETWEEN PROTECTIVE CASING AND WELL WITH SAND TO PROMOTE DRAINAGE

PROTECTIVE CASING
STEEL, STICK-UP, 4" DIA.

LOCK TYPE/KEY NUMBER
MASTER PADLOCK, NO. 2121

WELL CAP
2" J-PLUG

SURFACE SEAL
CONCRETE

ANNULAR FILL
RED FLINT SILICA SAND, 0.031-0.047"

SURFACE CASING
NONE

WELL RISER TYPE, DIA.
2" LOW-CARBON STEEL

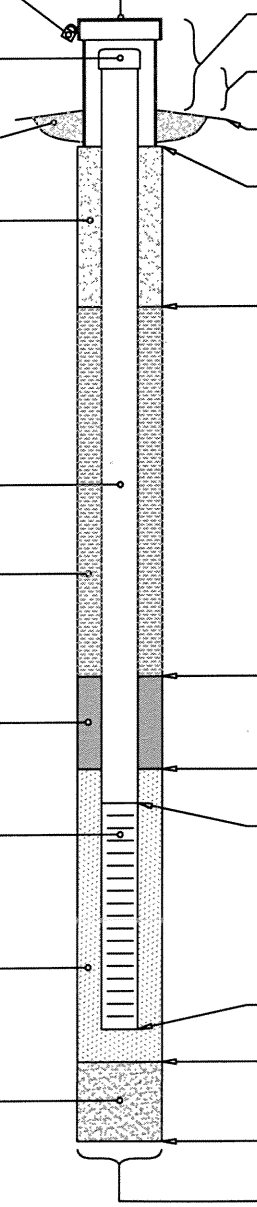
ANNULAR SEAL
HOLCIM AIR-ENTRAINING TYPE IA/GU PORTLAND CEMENT AND BAROID QUIK-GEL BENTONITE (6:1 MIXTURE BY WT)

FILTER PACK PROTECTION
RED FLINT SILICA SAND, 0.006"

SLOTTED PIPE
2" TYPE 304 STAINLESS, 0.01" HORIZ. SLOT

FILTER PACK
RED FLINT SILICA SAND, 0.031-0.047"

BOREHOLE BACKFILL
NONE



CASING HEIGHT ABOVE GROUND ~3 FEET

WELL HEIGHT ABOVE GROUND ~2.5 FEET

GROUND SURFACE

ANNULAR FILL, TOP 0.5 FEET

ANNULAR SEAL, TOP 1.5 FEET

ANNULAR SEAL, BOTTOM 53 FEET

FILTER PACK, TOP 58 FEET

SLOTTED PIPE, TOP 60 FEET

SLOTTED PIPE, BOTTOM 70 FEET

FILTER PACK, BOTTOM 70 FEET

BOREHOLE, BOTTOM 70 FEET

BOREHOLE DIA. 6 INCHES

NOT TO SCALE

POSITIVE DEPTHS DOWNHOLE FROM GROUND SURFACE
BOREHOLE DIAMETERS IN NOMINAL TERMS

I:\GEO\289 HIGHWAY 7 & WOODDALE AVE\LOGS\...

Minnesota Unique Well No.

216194

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 08/24/1991
Update Date 09/11/1991
Received Date

Well Name P-109

Township Range Dir Section Subsections Elevation 892 **ft.**

117 21 W 20 AABBAD **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth 44 **ft.** | **Depth Completed** 44 **ft.** | **Date Well Completed** 01/25/1980

Drilling Method --

Well Address

ST LOUIS PARK MN

Geological Material	Color	Hardness	From	To
FINE TO MEDIUM SILTY SAND FILL	BROWN		0	4
FINE TO MEDIUM SLIGHTLY SILTY SAN	BROWN		4	7
FINE TO MEDIUM SAND	BROWN		7	18
SANDY CLAYEY TILL	GRAY		18	20
FINE TO MEDIUM SAND	BRN/GRY		20	44

Drilling Fluid --

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Other (specify in remarks)

Casing Type **Joint** No Information **Drive Shoe?** ☐ Yes ☐ No **Above/Below** 0 **ft.**

Casing Diameter 0 in. to 42 ft. **Weight** lbs./ft. **Hole Diameter**

Open Hole from ft. to ft.

Screen YES **Make** **Type**

Diameter	Slot/Gauze	Length	Set Between
1.3		2	42 ft. and 44 ft.

Static Water Level
ft. from Date Measured

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☐ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

REMARKS
U.S.G.S. P-109

Located by: Minnesota Geological Survey
Method: Digitized - scale 1:24,000 or larger (Digitizing Table)
Unique Number Verification: Information from owner
Input Date: 01/01/1990
System: *UTM - Nad83, Zone15, Meters*
X: 471221 **Y:** 4975758

Grouting Information Well Grouted? ☐ Yes ☐ No

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number __ HP 0_ Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☐ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

Well Contractor Certification

License Business Name Lic. Or Reg. No. Name of Driller

First Bedrock
Aquifer
Last Strat sand-gray
Depth to Bedrock ft.

County Well Index Online Report

216194

Printed 11/20/2012
HE-01205-07

Minnesota Unique Well No.

216048

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 103I

Entry Date 08/24/1991
Update Date 06/08/2009
Received Date

Well Name MONITOR WELL W-20
Township Range Dir Section Subsections Elevation 893 **ft.**
117 21 W 20 AABABC **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth	Depth Completed	Date Well Completed
90 ft.	90 ft.	11/27/1978

Drilling Method --

Well Address

ST LOUIS PARK MN

Drilling Fluid --
Well Hydrofractured? Yes No
From Ft. to Ft.

Use Other (specify in remarks)

Geological Material	Color	Hardness	From	To
SAND	BROWN		0	5
SAND	BROWN		5	10
SAND	BROWN		10	15
SAND & GRAVEL	BROWN		15	20
SAND	BROWN		20	25
SAND	BROWN		25	30
SAND	BROWN		30	35
SAND	BROWN		35	40
SAND	BROWN		40	45
CLAY & GRAVEL	BROWN		45	50
CLAY & GRAVEL	BROWN		50	55
SAND & GRAVEL			55	60
GRAVEL	BROWN		60	65
GRAVEL	BROWN		65	69
LIMESTONE & SAND			69	75
LIMESTONE			75	80
NO RECORD			80	90

Casing Type **Joint** No Information **Drive Shoe?** Yes No **Above/Below** 0 **ft.**

Casing Diameter	Weight	Hole Diameter
4 in. to 80 ft.	lbs./ft.	

Open Hole from 80 ft. to 90 ft.

Screen NO **Make** **Type**

Diameter	Slot/Gauze	Length	Set Between

Static Water Level
17 ft. from Land surface Date Measured 11/27/1978

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
Casing Protection 12 in. above grade
At-grade (Environmental Wells and Borings ONLY)

NO REMARKS

Grouting Information Well Grouted? Yes No

Located by: Minnesota Geological Survey **Method:** Digitization (Screen) - Map (1:24,000)
Unique Number Verification: N/A **Input Date:** 06/02/2000
System: *UTM - Nad83, Zone15, Meters* **X:** 471244 **Y:** 4975760

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? Yes No

Pump Not Installed Date Installed
Manufacturer's name Model number __ HP 0 Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? Yes No

Variance Was a variance granted from the MDH for this well? Yes No

Cuttings Yes
First Bedrock Platteville Formation **Aquifer** Platteville
Last Strat no record **Depth to Bedrock** 75 **ft.**

Well Contractor Certification
Renner E.H. & Sons 27015
License Business Name Lic. Or Reg. No. Name of Driller

County Well Index Online Report **216048** Printed 11/20/2012 HE-01205-07

Table 1. Data on selected wells in the St. Louis Park area, Minnesota

Township and range: First three (or two) digits indicate township north of the baseline; next two digits indicate range north of the principal meridian; last digit(s) indicate(s) section in which well is located. Letters indicate well location in section: first letter denotes the 160-acre tract; second letter denotes the 40-acre tract; third letter denotes the 10-acre tract. Letters are assigned counterclockwise beginning with the northeast quarter. Consecutive numbers beginning with 1 are added as suffixes to distinguish wells within a given 10-acre tract.

Site identification (lat and long): First six digits are latitude of well location in degrees, minutes, and seconds; next seven digits are longitude in degrees, minutes, and seconds; last two digits are arbitrarily assigned to distinguish wells within a given 1-second by 1-second area.

Reported log: Qd, drift, undifferentiated; Opl, Platteville Limestone; Ogl, Glenwood Shale; Osp, St. Peter Sandstone, undifferentiated; Ospl, St. Peter Sandstone, lower siltstone beds; Opc, Prairie du Chien Group; Єj, Jordan Sandstone; Єsl, St. Lawrence Formation; Єf, Franconia Sandstone; Єig, Ironton and Galesville Sandstones; Єe, Eau Claire Sandstone; Єm, Mount Simon Sandstone; pЄh, Hinckley Sandstone.

Altitude: When MP is given, altitude is for measuring point, not land surface.

Field measurement status: A, well field located and permanently sealed or reconstructed; AH, well field located and permanently sealed by MDH; AR, well reported permanently sealed; BR, well reported filled; D, well field located and contains debris; F, well field located; G, well field located and geophysically logged; M, mass-measurement well (measured 2 to 3 times per year); O, observation well (measured every 2 to 3 weeks); P, well field located and has pump; X, well destroyed.

Township and range	Site identification (lat and long)	Minnesota unique well number	USGS project well number	Owner name or other identifiers	Driller	Date drilled	Reported log, in feet	Land surface altitude, in feet	Reported depth of well, in feet	Diameter, in inches, and depth, in feet, of casing	Aquifer(s) open to well bore	Water level, in feet	Date measured	Field measurement status
117.21.17 --- AAB1.	445654093215501	216030	W1	Monitoring well ----	E. H. Renner	-03-76	0–102 Qd 102–107 Opl	922.76 MP	107	4 in. 0–102	Opl	43.67	11-28-78	O
117.21.17 --- BAC1.	445651093222901	216031	W2	------ do ------	----- do -----	-03-76	0–36 Qd	897.14 MP	36	4 in. 0–32	Qd	10.40	11-28-78	O
117.21.17 --- BDB1.	445637093222401	216032	W3	------ do ------	----- do -----	-05-76	0–52 Qd	897	52	4 in. 0–49	Qd	7	05-10-76	D,X
117.21.17 --- CAD2.	445622093221901	216033	W5	------ do ------	----- do -----	-02-76	0–26 Qd	891.72 MP	26	4 in. 0–21	Qd	6.59	11-28-78	O
117.21.17 --- CAC1.	445620093222601	216034	W6	------ do ------	----- do -----	-02-76	0–26 Qd	892.74 MP	26	4 in. 0–22	Qd	7.39	11-28-78	O
117.21.17 --- CBD1.	445625093223601	216035	W7	------ do ------	----- do -----	-03-76	0–71 Qd	930	71	4 in. 0–66	Qd	35	03-02-76	D,X
117.21.17 --- CDD1.	445607093222101	216036	W8	------ do ------	----- do -----	-02-76	0–31 Qd	892.87 MP	31	4 in.	Qd	7.96	11-28-78	O
117.21.17 --- DCA1.	445614093220301	216037	W9	------ do ------	----- do -----	-02-76	0–25 Qd	891.21 MP	25	4 in. 0–20	Qd	7.13	11-27-78	O
117.21.20 --- ABD1.	445559093220201	216038	W10	------ do ------	----- do -----	-02-76	0–29 Qd	891.82 MP	29	4 in. 0–25	Qd	7.63	11-27-78	O
117.21.17 --- DDB2.	445614093215301	216039	W11	------ do ------	----- do -----	-11-76	0–23 Qd	897.20 MP	23	4 in. 0–19	Qd	13.63	11-27-78	O
117.21.17 --- DDA1.	445613093214001	216040	W12	------ do ------	----- do -----	-12-76	0–47 Qd	919.26 MP	47	4 in. 0–42	Qd	37.02	11-27-78	O
117.21.17 --- DCB1.	445615093220901	216041	W13	------ do ------	----- do -----	-11-76	0–50 Qd	890.40 MP	50	4 in. 0–45	Qd	6.19	11-28-78	O

Table 1. Data on selected wells in the St. Louis Park area, Minnesota—Continued

Township and range	Site identification (lat and long)	Minnesota unique well number	USGS project well number	Owner name or other identifiers	Driller	Date drilled	Reported log, in feet	Land surface altitude, in feet	Reported depth of well, in feet	Diameter, in inches, and depth, in feet, of casing	Aquifer(s) open to well bore	Water level, in feet	Date measured	Field measurement status
117.21.17 --- DCA2.	445614093220302	216042	W14	------ do ------	----- do -----	-02-77	0–68 Qd 68–82 Opl 82–85 Ogl 85–95 Osp	891.41 MP	95	8 in. 0–69 4 in. 0–86	Osp	23.75	11-27-78	G,O
117.21.17 --- CAC2.	445621093222601	216043	W15	------ do ------	----- do -----	-04-77	0–76 Qd	892.47 MP	76	4 in.	Qd	8.30	11-28-78	O
117.21.20 --- ABD2	445559093220202	216044	W16	------ do ------	----- do -----	-04-77	0–73.5 Qd	892.07 MP	64	4 in. 0–61	Qd	8.56	11-27-78	O
117.21.17 --- DDB3.	445614093215302	216045	W17	------ do ------	----- do -----	-04-77	0–69 Qd	897.07 MP	69	4 in. 0–66	Qd	14.05	11-27-78	O
117.21.17 --- DCA3.	445614093220303	216046	W18	------ do ------	----- do -----	1978	0–68 Qd 68–78 Opl	893.23 MP	78	4 in. 0–68	Opl	9.86	11-27-78	O
117.21.17 --- CDD2.	445607093222102	216047	W19	------ do ------	----- do -----	1978	0–72 Qd 71–81 Opl	894.43 MP	81	4 in. 0–81	Opl	11.22	11-28-78	O
117.21.20 --- AAB1.	445605093215101	216048	W20	------ do ------	----- do -----	1978	0–69 Qd 69–80 Opl	895.55 MP	80	4 in. 0–70	Opl	14.01	11-27-78	O
117.21.20 --- ABD3.	445559093220203	216049	W21	------ do ------	----- do -----	1978	0–87 Qd 87–92 Osp	892.60 MP	92	4 in. 0–92	Osp	24.27	11-27-78	O
117.21.17 --- CAA1.	445630093222101	200993	W22	Republic Creosote -- Washroom Well.	----- do -----	12-47	0–65 Qd 65–91 Opl 91–91 Osp	896.16 MP	91	4 in. 0–71	Originally Opl–Osp Now Opl.	11.44	11-28-78	G,O
117.21.17 --- CAD1.	445625093221601	216050	W23	Republic Creosote -- Site "Hinckley" well on site, Cooling well.	McCarthy	12-17 to 05-18.	0–60 Qd 60–95 Opl 95–195 Osp 195–258 Ospl 258–372 Opc 372–457 Єj 457–507 Єsl 507–835 Єf–Єe 835–909 Єm	894.49 MP	909	12 in. 0–65 10 in. 0–257 7 in. <230–373	Originally Єj,Єsl,Єf, Єig,Єe,Єm Now Osp, Opc, Єj,Єsl,Єf.	33.15	11-28-78	G,O
117.21.20 --- ABB1.	445604093220501	160018	W24	Monitoring well ----	E. H. Renner	-1978	0–81 Qd 81–83 Opl 83–86 Ogl 86–90 Osp	892.92 MP	90	8 in. 0–81.5 4 in. 0–86.7	Osp	22.84	11-27-78	O

W-23

603

Location________ Town St. Louis Park

Date Started Dec. 10, 1917 Machine No. 3 State Minn.

Date Completed May 13, 1918 Owner Republic Cresoting Co.

File No. Total Depth of Well 909

MP = 894.49

DIAMETER OF HOLE	20	16	12	10	8	6	4½	TOTAL
Top of Pipe below Surface			2	80	227			
Bottom of Pipe below Surface			65	257	373			
No. of Ft. of Pipe in the Hole			63	177	145			
No. of Ft. of Hole Drilled			258	115	536			909

TEST	1	2	3
Depth of the Hole	909	909	909
Depth to Water at Rest	46	46	17
Depth to Water Pumping	63	80	27
Depth of Pump Pipe	63	87	47
Size of Cylinder	8	8	8
Length of Stroke	28	34½	34
Strokes per Minute	25	43	49
Gallons per Minute	150	300	330
Will well supply more			yes
Was Strainer in Hole			
Hours putting in Pump			
Hours Pumping			
Hours taking out Pump			
Hours Consumed			

FORMATION	Thickness	Depth	Formation* I.D.
Limestone & Gravel	60	60	Qd
Limestone	35	95	Opl
Sand Rock	100	195	
Red Shale	15	210	
Sand Rock	4	214	
Red Shale	6	220	Osp
Sand Rock	6	226	
Red Shale	3	229	
Sand Rock Shaley	29	258	
Hard Rock	114	372	Opc
Sand Rock	85	457	Єj
Shaley Sand Rock	50	507	Єsl
Shale	138	645	Єf
Shale Sand Rock	67	712	Єig
Shale	69	781	Єe
Shaley Sand Rock	54	835	Єe
Sand Rock	72	907	Єms.
Shale & Sand Rock	2	909	

WL = 33' 11/78

STRAINER			
Make			
Diameter			
Total Length			
Number			
No. of Ft. Exposed			
Was Str. Sedged			
Did Sand come thru Str.			
Was Str. coarse enough			
Style of Fittings			

Dcan sip

NOTE:

The third test was made after the 10" pipe was cut off 80 feet - 6" below the surface.

* Added by ERT.

6230203

515958.

FIGURE 6-37

From USGS's 1981 report on the St. Louis Park problem.

A multiaquifer well can provide an avenue for the transport of contaminants and locally change the potentiometric surfaces of the aquifers that are connected. Water moves from one aquifer to another through multiaquifer wells in response to differences in water levels between aquifers. In the study area, the water level in each aquifer is higher than in underlying aquifers and flow through multiaquifer wells, therefore, is downwards.

As used in this report, a multiaquifer well is any well that hydraulically connects more than one aquifer (see glossary). The interconnection may be due to one or more of the following factors: (1) Original open-hole construction, (2) leaks in the casing, or (3) flow in the annular space between the casing and the bore hole. Detecting and measuring flow in the annular space outside casings generally requires specialized techniques that are beyond the scope of this study. References to flow through multiaquifer wells in this report are to flow inside the casing or in an uncased part of the well bore.

Uncased or ungrouted wells that penetrate more than one aquifer provide avenues for the transport of contaminants. The effect of an individual well depends on (1) the rate of flow down the well bore, (2) local and regional ground-water flow patterns, and (3) contaminant concentration. The rate of flow down the well bore depends primarily on the thickness and hydraulic conductivity of the aquifers, the head differences between them, and well construction and condition. For a given well of known original construction, the most difficult factor to estimate is present well condition because multiaquifer wells tend to be unstable, and casings deteriorate with time. A phenomenon known as "skin effect" occurs when the pores of the aquifer into which water flows are clogged by sediment, biologic films, or chemical encrustation.

Well W23 ("Hinckley" well on the site; table 1, fig. 3, and pl. 1) is a multiaquifer well that is particularly important because the well bore is partly filled with coal-tar. When drilled in 1917, the well was 909 feet deep and may have permitted the flow of water out of the Prairie du Chien-Jordan aquifer and into the underlying Ironton-Galesville and Mount Simon-Hinckley aquifers. By early 1977, however, water was moving into the Prairie du Chien-Jordan aquifer from the overlying St. Peter aquifer. A downhole television camera survey and geophysical logging in 1978 showed that the well was 595 feet deep, visibly contaminated, and that water was entering the well bore through holes in the casing adjacent to the St. Peter Sandstone (fig. 13). About 150 gal/min of water was leaking into the well bore, flowing downward, and entering the Prairie du Chien through another hole in the casing.

The estimate of flow was made from independent measurements through use of the television camera and an impeller-type velocity probe that was approximately calibrated in the hole. Methods of flow measurement in well bores are discussed by Patten and Bennett (1962).

Periodic water-level measurements and a second television survey confirmed that the flow was sustained. In July 1979, the city of St. Louis Park had a temporary packer installed in the well to stop the flow. The well was equipped in 1979 with digital recorders to obtain water levels above the packer (St. Peter aquifer) and below the packer (Prairie du Chien-Jordan aquifer and St. Lawrence-Franconia confining bed).

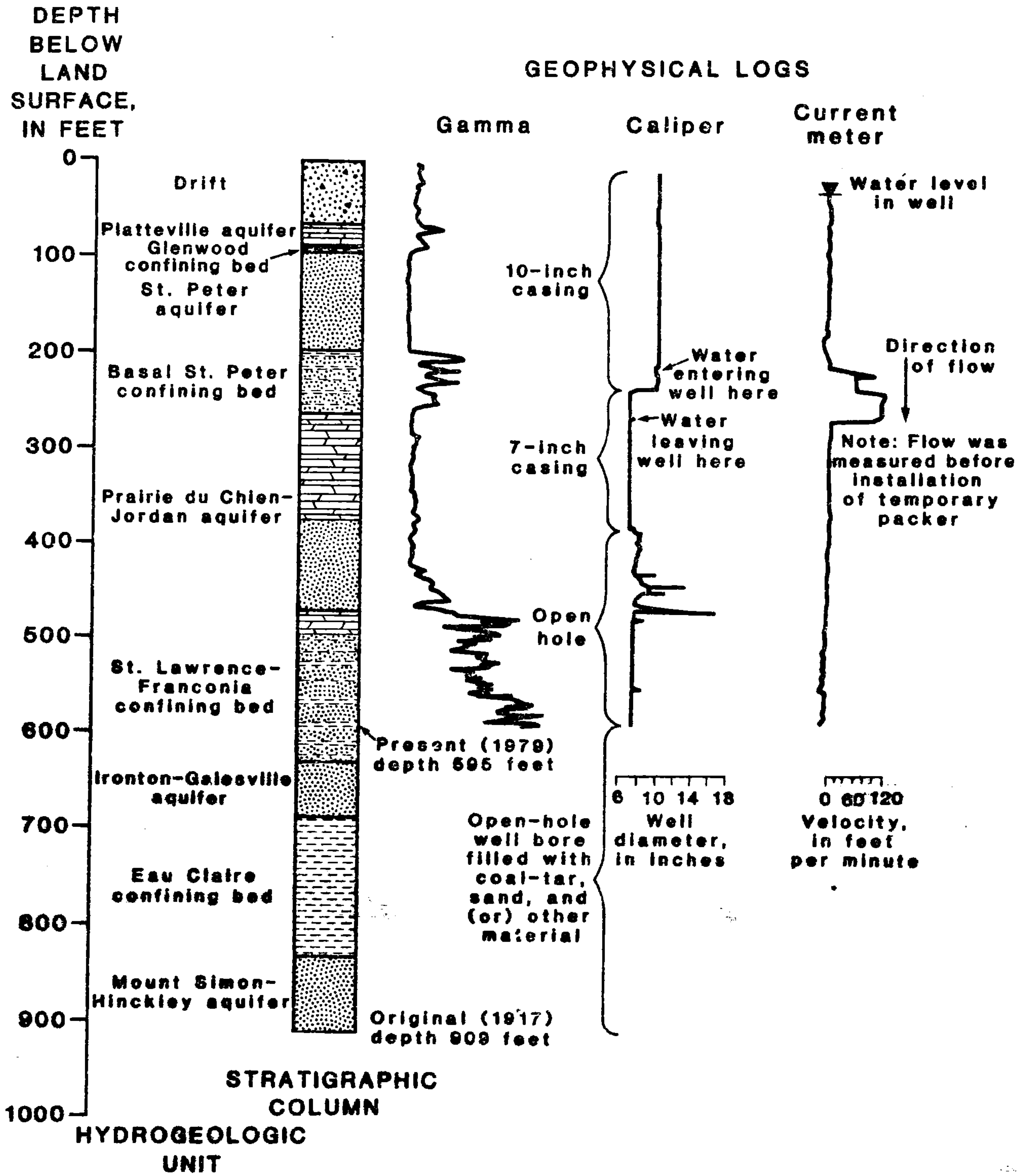


Figure 13.--Geologic and geophysical logs of well W23 ("Hinckley" well on the site)

105332

A multiaquifer well changes the direction of ground-water flow in the vicinity of the well. A cone of depression is created in the aquifer of higher head by withdrawal of water from it; conversely, a cone of impression is created in the aquifer of lower head by the flow of water into it (fig. 14). The shape and area of influence of these cones depends on the rate of flow, aquifer characteristics, head differences, stresses, such as pumping wells and flow through other multiaquifer wells, and hydrogeologic boundaries, such as drift-filled bedrock valleys. For instance, figure 15 indicates a gradient in the St. Peter aquifer toward well W23. This may be due both to a cone of depression in this aquifer caused by flow out of the aquifer through the well and increased recharge to the St. Peter aquifer from the drift-filled valley near well W24.

The water level in a multiaquifer well reflects the cone of impression or depression in each aquifer to which it is hydraulically connected. If well loss, skin effects, and head differences needed for flow to occur within the well bore are negligible, the water-level altitude in a multiaquifer well is equal to the potentiometric head in each aquifer to which it is open.

A cone of impression caused at least in part by well W23 was formed in the Prairie du Chien-Jordan aquifer at the site. Static water levels measured by the U.S. Geological Survey on August 23, 1977, at five St. Louis Park municipal wells (SLP5, SLP8, SLP9, SLP10, and Old SLP1) completed in the Prairie du Chien-Jordan aquifer are shown in plate 1. The water level in well W23 is higher than the water levels measured in surrounding wells constructed in the Prairie du Chien-Jordan aquifer, therefore it indicated that a cone of impression had been created by water moving through the well bore of well W23 from the overlying St. Peter aquifer. The water level in well W23 shown on plate 1 was not measured in August 1977, but an estimate was made for this date from 18 measurements since April 1978 and a water level in the spring of 1977 inferred from Barr (1977, p. III-34).

The data indicate that on August 23, 1977, water in the Prairie du Chien-Jordan aquifer was moving away from W23 in all directions but that the hydraulic gradient was steepest between W23 and the municipal well field to the north. The gradient to the north has decreased since this time in apparent response to the interruption in use of four municipal wells in the Prairie du Chien-Jordan aquifer (figs. 9, 10, and pl. 1). These wells were found to be contaminated in 1978 (Minnesota Department of Health, 1978).

Four other wells have been located that were causing water to flow into the Prairie du Chien-Jordan aquifer from overlying aquifers (Wolfe Lake Well, W69; Hedberg-Friedhiem, W114; Burdick Grain, W47; Prestolite, W50). These wells were sampled by the Minnesota Department of Health. Each has been permanently sealed with grout. Water pumped from wells W114 and W50 had a distinct chemical odor at the time of sampling. Chemical analysis of water pumped from well W47 did not indicate significant quantities of contaminants.

The permeability of the upper part of the Prairie du Chien-Jordan aquifer (Prairie du Chien Group) is due to solution channels and open joints (pl. 2; geologic and water-bearing characteristics of hydrogeologic units). These openings are large compared to the intergranular pores of sandstone and are less water table and vertical movement of contaminated water and hydrocarbon-fluid phase into underlying, confined drift aquifers. Visible contamination extends at least 50 feet below the water table south of the site near well W13 (Minnesota Department of Health, 1974; Barr, 1976).

Since at least 1938, most of the surface water inflow to the ponds was recharged to the underlying peat and Middle Drift aquifer. The inflow included 30 to 60 gal/min of wastewater (Minnesota Department of Health, 1938) and as much as several hundred gallons per minute of runoff during peak periods. This added inflow raised the water level in the ponds and increased vertical leakage. The water table at well W13 was at or slightly below land surface during June 1978 to June 1979, but inspection of areal photographs since 1938 shows that, previously, this area was a pond and that the water table was above the present land surface. The reduction in the water-table mound is attributed to cessation of plant-process water discharges and construction of storm sewers since the plant closed in 1972. Maps in this report show the approximate extent of this pond. However, the pond on the site and the pond south of Lake Street shown on maps in this report are part of the storm-sewer system. They were constructed with impermeable bottom materials to prevent leakage.

The composition of contaminants that entered the ground-water system through the ponds may have been more consistent than the composition of spills and drippings on the site itself. Approximately 2 percent of the raw coal tar as received by the plant was water. The "2-percent cut" was removed from the coal tar and discharged. Discharge from this process may have been enriched with highly soluble compounds. In addition, sodium hydroxide and sulfuric acid were used at various times in plant processing. Between 1940 to 1943, for example, about 80,000 gallons of 70 percent sodium hydroxide was used and discharged to the ponds.

The third major path by which contaminants reached the ground-water system was through at least one well on the site. Well W23 (fig. 13, table 1) was originally drilled in 1917 to a depth of 909 feet but is now 595 feet deep and partly filled with coal tar. A spill may have occurred about 1930. In 1958, a well driller attempted to remove the viscous material by bailing, but was unsuccessful. A core sample of the upper 1 foot of the fill material, which was taken by the U.S. Geological Survey in 1979, consists of sand-sized quartz grains and tar. The amount and maximum depth of the coal tar in the well is unknown.

Well W23 may have been a source of early contamination reported in the Prairie du Chien-Jordan aquifer. The effect it has had on water quality in the Ironton-Galesville and Mount Simon-Hinckley aquifers, if any, is unknown.

Chemical Quality in the Drift-Platteville Aquifer System

Samples were collected from 25 wells in March-April 1979 to define the extent and nature of contamination and the natural hydrogeochemical system on which the contamination is superposed. Data on approximately 50 chemical constituents or fluid properties are presented in table 4.

ENSR W-33R

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes, Chapter 103I

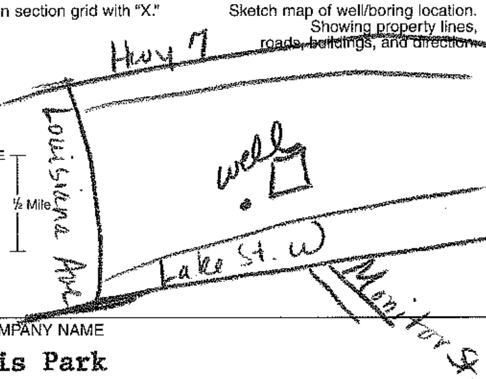
MINNESOTA UNIQUE WELL AND BORING NO. **753534**

WELL OR BORING LOCATION

County Name	Hennepin
Township Name	St. Louis Park
Township No.	28N
Range No.	21W
Section No.	17
Fraction	¼ NE ¼ SW ¼
GPS LOCATION	Latitude ____ degrees ____ minutes ____ seconds ____ / Longitude ____ degrees ____ minutes ____ seconds ____
House Number, Street Name, City, and Zip Code of Well Location	7020 West Lake St, St. Louis Park
or Fire Number	

Show exact location of well/boring in section grid with "X." (N, S, E, W; ½ Mile; 1 Mile)

Sketch map of well/boring location. Showing property lines, roads, buildings, and direction.



PROPERTY OWNER'S NAME/COMPANY NAME

City of St. Louis Park

Property owner's mailing address if different than well location address indicated above.

5005 Minnetonka Blvd
St. Louis Park, MN 55416

WELL OWNER'S NAME/COMPANY NAME

City of St. Louis Park

Well/boring owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIALS	COLOR	HARDNESS OF MATERIAL	FROM	TO
backfill	black		0	10
gravel & sand	mixed		10	70
rock	gray	hard	70	87
shale	gray		87	92
sandstone	yellow	soft	92	100
sandstone	white	soft	100	150
sandstone	white	hard	150	183

Use a second sheet, if needed.

REMARKS, ELEVATION, SOURCE OF DATA, etc.

W33R

IMPORTANT - FILE WITH PROPERTY PAPERS
WELL OWNER COPY

753534

IC 140-0020

WELL/BORING DEPTH (completed) 183 ft.

DATE WORK COMPLETED July 17, 2007

DRILLING METHOD
☐ Cable Tool ☐ Driven ☐ Dug
☐ Auger ☒ Rotary ☐ Jetted
☐ ____

DRILLING FLUID bentonite

WELL HYDROFRACTURED? ☐ Yes ☒ No — From ____ ft. To ____ ft.

USE
☐ Domestic ☒ Monitoring ☐ Heating/Cooling
☐ Noncommunity PWS ☐ Environ. Bore Hole ☐ Industry/Commercial
☐ Community PWS ☐ Irrigation ☐ Remedial
☐ Elevator ☐ Dewatering ☐ ____

CASING MATERIAL
☒ Steel 4" — Drive Shoe? ☒ Yes ☐ No — ☒ Threaded ☒ Welded 10"
☐ Plastic ☐ ____

CASING

Diameter		Weight	Specifications	HOLE DIAM.
10 in. to 0 ft.		90 lbs./ft.		16 in. to 90 ft.
4 in. to 0 ft.		163 lbs./ft.	9	7/8 in. to 163 ft.
in. to ft.		lbs./ft.		in. to ft.

SCREEN ____ Make ____ Type ____ Diam. ____ Slot/Gauze ____ Length ____ Set between ____ ft. and ____ ft. FITTINGS ____

OPEN HOLE From 163 ft. To 183 ft.

STATIC WATER LEVEL 45 ft. ☒ Below ☐ Above land surface — Measured from grade — Date measured 7/16/07

PUMPING LEVEL (below land surface) ____ ft. after ____ hrs. pumping 30+ g.p.m.

WELLHEAD COMPLETION
☐ Pitless/adapter manufacturer ____ Model ____
☒ Casing Protection 10" x 90 ☒ + in. above grade 24"
☐ At-grade (Environmental Well and Boring ONLY)

GROUTING INFORMATION
Well grouted ☒ Yes ☐ No
Grout materials ☒ Neat cement ☐ Bentonite ☐ Concrete ☐ Other ____

	From	To		Amount	
10"	0	90	ft.	58	☐ Yds. ☒ Bags
4"	0	163	ft.	70	☐ Yds. ☒ Bags
			ft.		☐ Yds. ☐ Bags

NEAREST KNOWN SOURCE OF CONTAMINATION ____ feet ____ direction ____ type

Well disinfected upon completion? ☐ Yes ☒ No

PUMP
☒ Not installed Date installed ____
Manufacturer's name ____
Model Number ____ HP ____ Volts ____
Length of drop pipe ____ ft. Capacity ____ g.p.m.
Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ ____

ABANDONED WELLS
Does property have any not in use and not sealed well(s)? ☐ Yes ☒ No

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN# ____

WELL CONTRACTOR CERTIFICATION
This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Stevens Drilling & Env. Svc Inc — 2255
Licensee Business Name — Lic. or Reg. No.

[signature] — 86654 — 7/19/07
Certified Representative Signature — Certified Rep. No. — Date

Randy Johnson
Name of Driller

HE-01205-10 (Rev. 6/06)

Minnesota Unique Well No.

165578

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 08/24/1991
Update Date 06/03/2004
Received Date

Well Name U.S.G.S. WELL W-122

Township Range Dir Section Subsections Elevation 920 **ft.**

117 21 W 21 BADBCD **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth	Depth Completed	Date Well Completed
239 ft.	239 ft.	08/06/1979

Drilling Method --

Well Address

ST LOUIS PARK MN

Drilling Fluid --

Well Hydrofractured? Yes No
From Ft. to Ft.

Use Other (specify in remarks)

Geological Material	Color	Hardness	From	To
SAND & GRAVEL	YELLOW		0	33
CLAY & GRAVEL	TAN		33	55
SAND	BROWN		55	70
MUDDY SAND & GRAVEL	BROWN		70	120
SANDSTONE & GRAVEL	WHITE		120	237
SHALE	BRN/GRN		237	239

Casing Type **Joint** No Information **Drive Shoe?** Yes No **Above/Below** 0 **ft.**

Casing Diameter 4 in. to 217 ft. **Weight** lbs./ft. **Hole Diameter**

Open Hole from 217 ft. to 239 ft.

Screen NO **Make** **Type**

Diameter **Slot/Gauze** **Length** **Set Between**

Static Water Level
35 ft. from Land surface Date Measured 08/06/1979

PUMPING LEVEL (below land surface)
35 ft. after hrs. pumping 15 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
Casing Protection 12 in. above grade
At-grade (Environmental Wells and Borings ONLY)

REMARKS
GAMMA LOGGED 10/9/79.

Grouting Information Well Grouted? Yes No

Located by: Minnesota Geological Survey
Method: Digitized - scale 1:24,000 or larger (Digitizing Table)
Unique Number Verification: N/A
Input Date: 01/01/1990
System: *UTM - Nad83, Zone15, Meters* **X:** 472170 **Y:** 4975504

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? Yes No

Pump Not Installed Date Installed
Manufacturer's name Model number __ HP 0 Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? Yes No

Variance Was a variance granted from the MDH for this well? Yes No

Borehole Geophysics Yes
First Bedrock St.Peter Sandstone
Last Strat St.Peter Sandstone
Aquifer St.Peter
Depth to Bedrock 120 **ft.**

Well Contractor Certification
Renner E.H. & Sons — License Business Name
02015 — Lic. Or Reg. No.
Name of Driller

County Well Index Online Report

165578

Printed 8/21/2012
HE-01205-07

Preliminary Evaluation of Ground-Water Contamination by Coal-Tar Derivatives, St. Louis Park Area, Minnesota

By MARC F. HULT and MICHAEL E. SCHOENBERG

Prepared in cooperation with the
Minnesota Department of Health

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2211

Table 1. Data on selected wells in the St. Louis Park area, Minnesota—Continued

Township and range	Site identification (lat and long)	Minnesota unique well number	USGS project well number	Owner name or other identifiers	Driller	Date drilled	Reported log, in feet	Land surface altitude, in feet	Reported depth of well, in feet	Diameter, in inches, and depth, in feet, of casing	Aquifer(s) open to well bore	Water level, in feet	Date measured	Field measurement status
117.21.16 --- DCB3.	445634093205903	160030	W116	do	E. H. Renner	-04-79	0-67 Qd	909.59	67	0-4 in. 0-63	Qd	35.01	06-05-79	O
117.21.16 --- CDB3.	445617093211502	160031	W117	do	do	-04-79	0-72 Qd	917.73 MP	72	4 in. 0-68	Qd	39.68	06-05-79	O
117.21.20 --- CDC1.	445516093222501	216088	W118	Minneapolis Park Board-Meadowbrook Golf Course.	do		0-80 Qd 80-89 Opl 89-245 Osp 245-370 Opc 370-485 Ꞓj 485-487 Ꞓsl	905	487	—	Opc-Ꞓsl	—	—	—
117.21.20 --- DAC1.	445527093215201	216009	W119	do		-06-35	0-74 Qd 74-82 Opl 82-90 Ogl 90-252 Osp 252-375 Opc 375-465 Ꞓj 465-502 Ꞓsl	890	502	16 in. 0-77 12 in. 77-257	Opc-Ꞓsl	54.5	06-28-35	—
117.21.16 --- DCA2.	445014093212802	165516	W120	Monitoring well	E. H. Renner	-07-79	0-95.5 Qd 95.8-98 Opl, (weathered) 98-107 Opl 107-108.6 Ogl	919.8 MP	105.7	4 in. 0-98	Opl	38.84	07-12-79	G,O
117.21.21 --- BBD1.	445558093212001	165577	W121	do	do	-07-79	0-110 Qd 110-115 Opl, (weathered) 115-117 Ogl	918	113.25	4 in. 0-109	Opl	53.58	07-18-79	G,O
117.21.21 --- BAD1.	445557093210901	165578	W122	do	do	-08-79	0-120 Qd 120-212 Osp 212-239 Ospl	920	239	4 in. 0-217	—	—	—	G,O
117.21.21 --- BBC1.	445559093213201	216129	W140	Cambridge Brick			—	—	—	4 in.	Opl?	—	—	D
117.21.17 --- DDD5.	445607093214203	216051	W143	6425 Oxford St.			0-70 Qd 70-90 Opl	—	—	4 in. 0-70	Opl	—	—	G
28.24.06 --- BCD2.	445634093204102	216128	W144	Interior Elevator			—	—	—	—	—	—	—	F

NUCLEAR LOG

TYPE: Natural GAMMA DATE: 9 Oct 79

LOCATION: State MINN County Hennepin Town St Louis Park

U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION

District or Project:

FILE LOCATION NO.:

CONFIDENTIAL PURSUA
TO COURT ORDER

LOGGING INFORMATION

Operator(s) USGS - McCullough
Equipment Address: DFC Denver Colo
Logger type: Well Recon No. Comprobe
Tool type: do
Detector type:
Source type:
Source size: C; MC
Source spacing:
Tool length, cable head to detector .11 ft in
Calibration: See log cps
Logging speed: 17 ft/min up down
Log vert. scale: 20 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 0-50 cps chart div (or) full scale (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or suppression): 10 Dial Div.
Sensitivity Pot. (Span): 10 Dial Div.
Discrimination Pot.: 8.58 Dial Div.
Input pulse: 12 volts; Polarity Neg
Output switch: normal; reverse
Actual scale: cps / API chart div (or) full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:			
Sensitivity Pot.:			

Run No. of

Remarks:

WELL INFORMATION

Well No. (USGS): Well W122 ST. Louis Park
Other:
Map or Quad
Site description

Agency or Owner: USGS
Address:
Altitude of L.S.
Log M.P. Top 4" Log TD 232 ft
Btm log interval: ft
Top log interval: ft Well TD: 239 ft
Type of finish:
Casing: Elev. of top ft/in Above Below L.S.

I.D. 4", from 3.6 to 217, type
I.D. , from to , type
I.D. , from to , type

Cement: from to

Perf. interval(s) from to , type
Open hole diameter: from to
from to

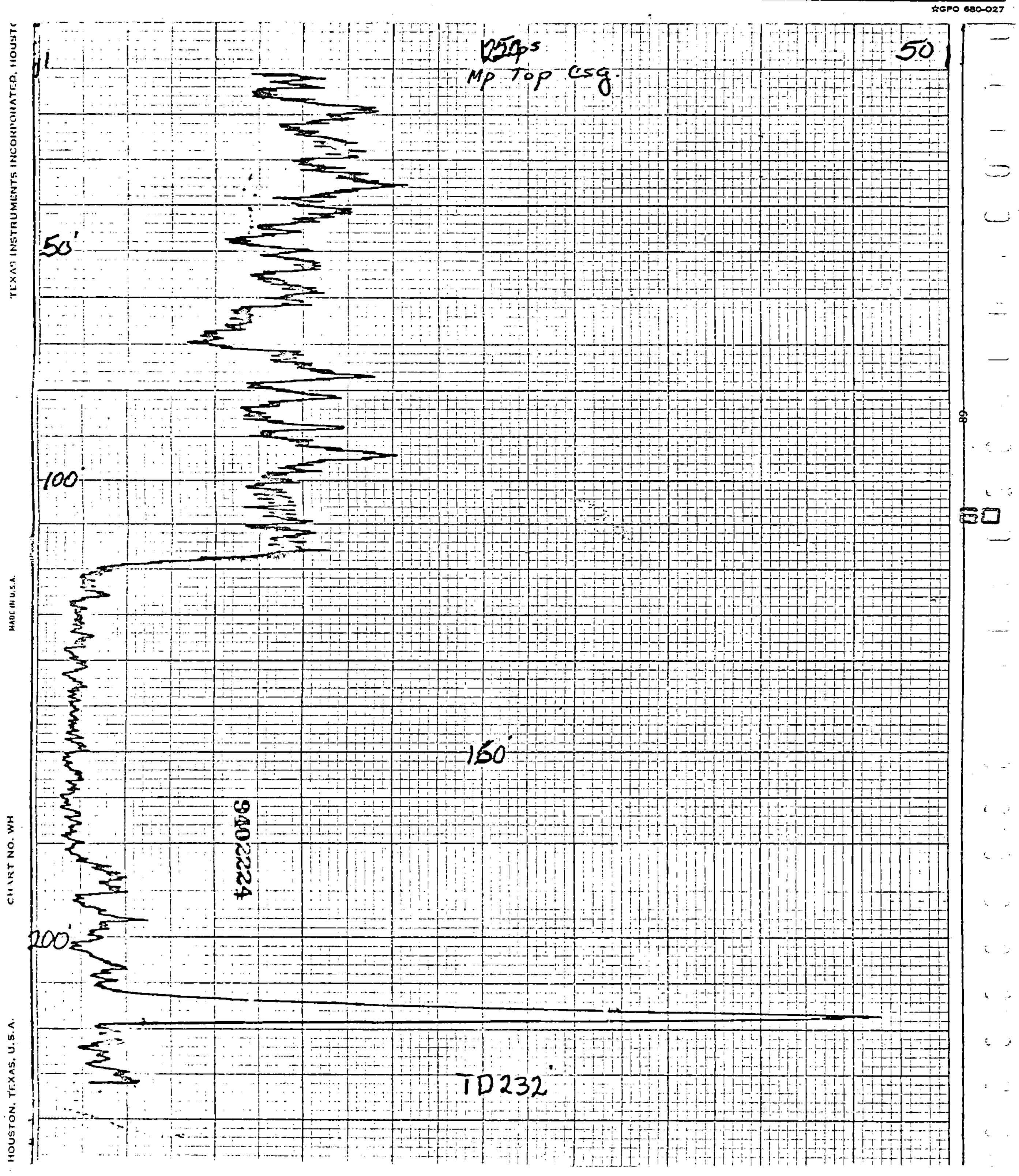
Fluid level: ft/in Above At Below L.S., Top Csg

Fluid type: temp °F, °C
Fluid resist.: ohm-m
Driller:
Address:
Type of rig:
Date started: completed
Aquifer or formation:

NOTE: This log is not to be used to fulfill private contractua obligations.

Other data and logs available for this well:

☆GPO 680-027



NUCLEAR LOG

U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION

PE: Neutron DATE: 9 Oct 79

District or Project:

CATION: State MINN County Hennepin Town St Louis Park FILE LOCATION NO.:

CONFIDENTIAL PURSUANT TO COURT ORDER

LOGGING INFORMATION

erator(s): USGS Mc Cullough
uipment Address: DFC Denver Colo
gger type: Well Recon No. Comprobe
ol type: do
tector type: scintillation
urce type: AmBe
urce size: 3 C MC
urce spacing: 10" Spacer
ol length, cable head to detector 11 ft in
libration: See log cps
gging speed: 17 ft/min up down
g vert. scale: 20 ft/in

MODULE SETTINGS

ale switch (rate or counts): 0-100 cps chart div (or) 0-500 full scale (circle as applicable)

C. switch: 4 sec.
sition Pot. (Base, zero, or suppression) 10 & 95 Dial Div.
nsitivity Pot. (Span): 40 & 35 Dial Div.
scrimination Pot.: 858 Dial Div.
put pulse: 1.2 volts; Polarity Neg
itput switch: normal; reverse
tual scale: cps chart div (or) API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
sition Pot.:			
nsitivity Pot.:			

n No. of

marks:

WELL INFORMATION

Well No. (USGS): Well W122 ST Louis Park
Other:
Map or Quad
Site description

Agency or Owner: USGS
Address:
Altitude of L.S.
Log M.P. Top Csg Log TD 231 ft
Btm log interval: ft Well TD: 239 ft
Top log interval: ft
Type of finish:
Casing: Elev. of top ft/in Above Below L.S.

I.D. 4", from 3.6' to 217, type Steel
I.D. , from to , type
I.D. , from to , type

Cement: from to

Perf. interval(s) from to , type
Open hole diameter: from to
from to

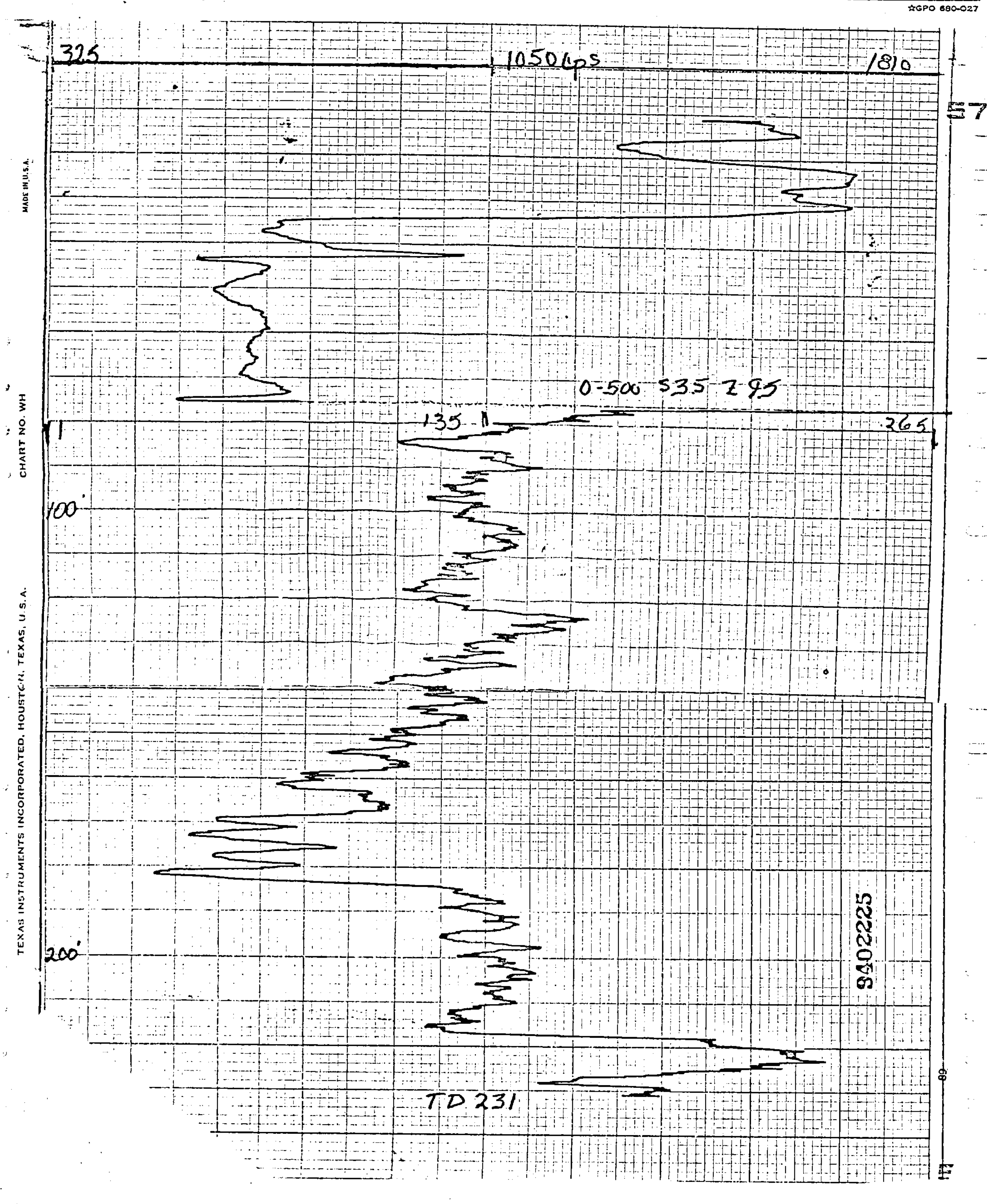
Fluid level: 76.4 ft/in Above At Below L.S., Top Csg

Fluid type: WTR , temp °F, °C
Fluid resist.: ohm-m
Driller:
Address:
Type of rig:
Date started: completed
Aquifer or formation:

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well:

☆GPO 680-027



NUCLEAR LOG

TYPE: GAMMA-GAMMA DATE: 9 Oct '79

LOCATION: State MINN County Hennepin Town ______

LOGGING INFORMATION

Operator(s) USGS - McCullough
Equipment Address: DFC Denver, Colo
Logger type: Well Recon No. Comprobe
Tool type: do
Detector type: Scintillation
Source type: Cs 137
Source size: ______ C: 325 MC
Source spacing: 18" spacer
Tool length, cable head to detector 11 ft ____ in
Calibration: See log . ____ cps
Logging speed: 17 ft/min up down
Log vert. scale: 20 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 0-1K cps } chart div (or) API } full scale (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or suppression 965 & 80 Dial Div.
Sensitivity Pot. (Span): 4.0 & 3.5 Dial Div.
Discrimination Pot.: 858 Dial Div.
Input pulse: 12 volts; Polarity Neg
Output switch: normal; reverse
Actual scale: ______ cps } chart div (or) ______ API } full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:			
Sensitivity Pot.:			

Run No. ______ of ______

Remarks: ______

U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION

District or Project: ______ CONFIDENTIAL PURSUANT
FILE LOCATION NO.: ______ TO COURT ORDER
DRAFT

WELL INFORMATION

Well No. (USGS): Well - W122 St Louis Park
Other: ______
Map or Quad ______
Site description ______

Agency or Owner: USGS
Address: ______
Altitude of L.S. ______
Log M.P. Top 4" Csg Log TD 231 ft
Btm log interval: 0 ft Well TD: ~~240~~ 239 ft
Top log interval: ______ ft
Type of finish: ______
Casing: Elev. of top ______ ft/in Above Below L.S.

I.D. 4", from -3.6' to 217, type Steel
I.D. ______, from ______ to ______, type ______
I.D. ______, from ______ to ______, type ______

Cement: from ______ to ______

Perf. interval(s) from ______ to ______, type ______
Open hole diameter: ______ from ______ to ______
from ______ to ______

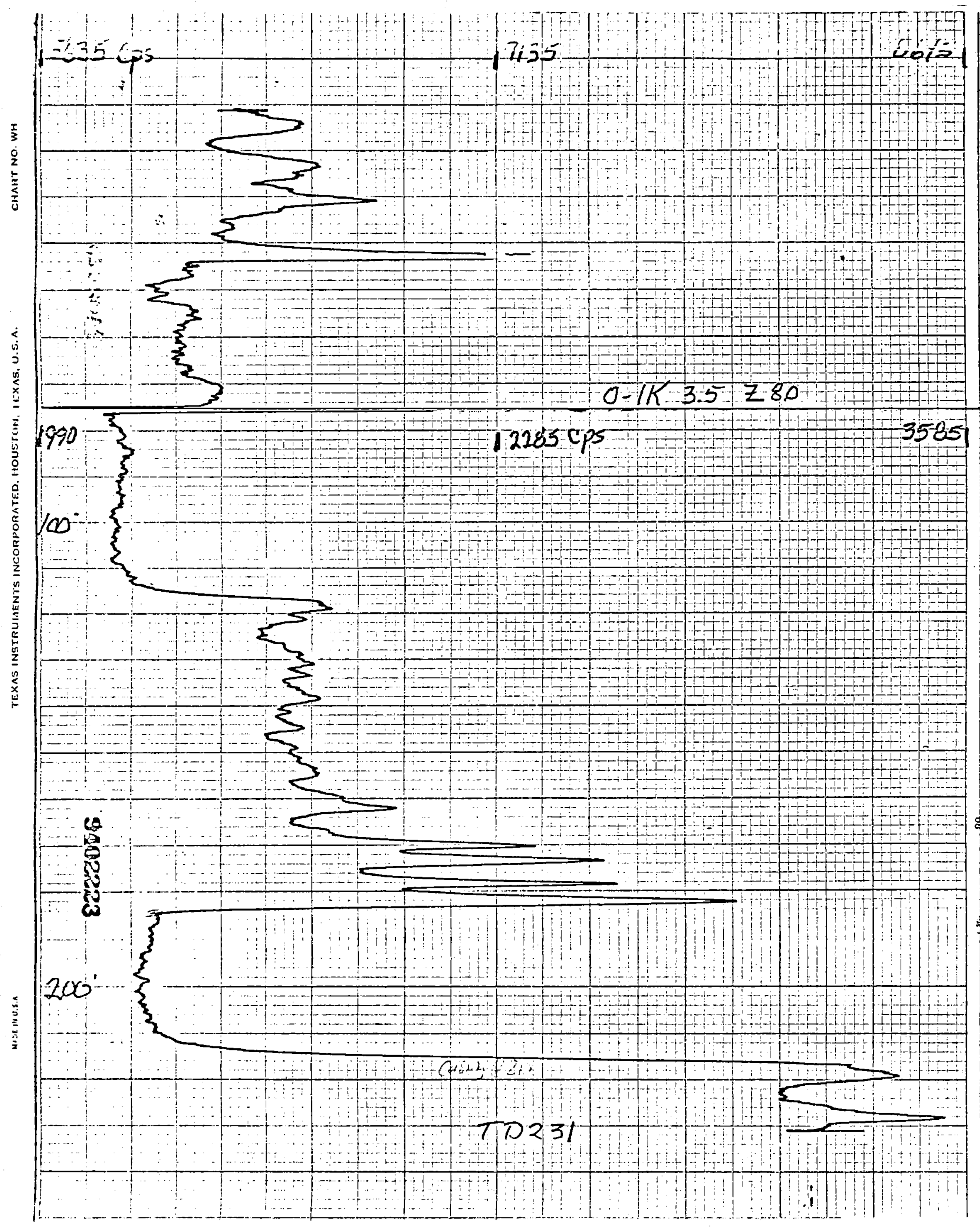
Fluid level 76.4 ft/in Above At Below L.S., Top Csg

Fluid type: WTR, temp ______ °F, °C
Fluid resist.: ______ ohm-m
Driller: ______
Address: ______
Type of rig: ______
Date started: ______ completed ______
Aquifer or formation: ______

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well: ______

☆GPO 680-027



59

Minnesota Unique Well No.

165584

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 08/24/1991
Update Date 09/11/1991
Received Date

Well Name U.S.G.S WELL NO. 129

Township Range Dir Section Subsections Elevation 913 **ft.**

117 21 W 21 BCDDAA **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth	Depth Completed	Date Well Completed
122 **ft.**	122 **ft.**	10/23/1979

Drilling Method --

Well Address
3984 ALABAMA
ST LOUIS PARK MN

Drilling Fluid --

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Test well

Geological Material	Color	Hardness	From	To
TOP SOIL	BLACK		0	5
CLAY	YELLOW		5	15
CLAY & GRAVEL	YELLOW		15	97
GRAVEL & SAND	VARIED		97	103
LIME & SAND & GRAVEL	VARIED		103	117
SANDSTONE			117	122

Casing Type **Joint** No Information **Drive Shoe?** ☐ Yes ☐ No **Above/Below** 0 **ft.**

Casing Diameter	Weight	Hole Diameter
4 in. to 118 ft.	lbs./ft.	

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON **Type** stainless steel

Diameter	Slot/Gauze	Length	Set Between
2	10	5	117 ft. and 122 ft.

Static Water Level
24 ft. from Land surface Date Measured 10/23/1979

PUMPING LEVEL (below land surface)
0 ft. after hrs. pumping 5 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☐ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

NO REMARKS

Grouting Information Well Grouted? ☐ Yes ☐ No

Located by: Minnesota Geological Survey

Method: Digitized - scale 1:24,000 or larger (Digitizing Table)

Unique Number Verification: Information from owner

Input Date: 01/01/1990

System: *UTM - Nad83, Zone15, Meters*

X: 471901 **Y:** 4975078

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number __ HP 0 Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☐ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

First Bedrock St.Peter Sandstone

Aquifer St.Peter

Last Strat St.Peter Sandstone

Depth to Bedrock 117 **ft.**

Well Contractor Certification

Renner E.H. & Sons	02015	
License Business Name	Lic. Or Reg. No.	Name of Driller

County Well Index Online Report

165584

Printed 11/7/2012
HE-01205-07

Minnesota Unique Well No.

439751

County Hennepin
Quad Minneapolis South
Quad ID 104A

Well W403

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 11/24/1992
Update Date 04/15/2008
Received Date

Well Name ST. LOUIS PARK B7-22

Township Range Dir Section Subsections Elevation 865 **ft.**

28 24 W 7 AACADD **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth	Depth Completed	Date Well Completed
385 **ft.**	385 **ft.**	03/01/1988

Drilling Method Non-specified Rotary

Well Address
INGLEWOOD & 39TH ST
MN

Geological Material	Color	Hardness	From	To
SANDY SOIL	YELLOW	SOFT	0	15
PEAT	BLACK	SOFT	15	50
GRAVEL	BRN/BLK	MED-HRD	50	66
PLATTEVILLE	GRAY	HARD	66	68
GLENWOOD	GREEN	MEDIUM	68	92
ST. PETER	WHITE	MEDIUM	92	230
PRAIRIE DU CHIEN	RED	HARD	230	382
JORDAN	WHITE	SOFT	382	385

Drilling Fluid Bentonite

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Irrigation

Casing Type Steel (black or low carbon) **Joint** Threaded **Drive Shoe?** ☐ Yes ☑ No **Above/Below** 2 **ft.**

Casing Diameter	Weight	Hole Diameter
10 in. to 68 ft.	40.48 lbs./ft.	15 in. to 70 ft.
5 in. to 235 ft.	14.62 lbs./ft.	10 in. to 235 ft.

Open Hole from 235 ft. to 385 ft.

Screen NO **Make** **Type**

Diameter **Slot/Gauze** **Length** **Set Between**

Static Water Level
30 ft. from Land surface Date Measured 02/26/1988

PUMPING LEVEL (below land surface)
0 ft. after hrs. pumping 50 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

REMARKS
INGLEWOOD & 39TH ST. - IN PARK
M.G.S. NO. 3443.

Located by: Minnesota Department of Health
Method: Digitization (Screen) - Map (1:12,000)
Unique Number Verification: Information from owner
Input Date: 06/16/2005
System: *UTM - Nad83, Zone 15, Meters*
X: 473824 **Y:** 4975388

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: Bentonite from 0 to 235 ft. 3.5 yrds.
Grout Material: Neat Cement from 0 to 68 ft. 2 yrds.

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number _ HP 0 Volts
Length of drop Pipe _ ft. Capacity _ g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☐ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

Cuttings Yes
First Bedrock Platteville Formation
Last Strat
Aquifer Multiple
Depth to Bedrock 66 **ft.**

Well Contractor Certification

27057

License Business Name Lic. Or Reg. No. Name of Driller

Minnesota Unique Well No.

434042

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 103I

Entry Date 01/14/2009
Update Date 01/14/2009
Received Date

Well Name W-410

Township	Range	Dir	Section	Subsections	Elevation	ft.
117	21	W	17		Elevation Method	

Well Depth	Depth Completed	Date Well Completed
185 ft.	125 ft.	09/20/1989

Drilling Method Multiple methods used

Well Address
6425 OXFORD ST
ST LOUIS PARK MN 55416

Drilling Fluid Bentonite

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Monitor well

Geological Material	Color	Hardness	From	To
SAND	BROWN	SOFT	0	15
CLAYEY SAND	BROWN	MEDIUM	15	25
SILTY F. SAND; T. GRAVEL	BROWN	MEDIUM	25	55
MED. GRAVEL; T. SAND	VARIED	HARD	55	78
PLATTEVILLE LIMESTONE	GRAY	V.HARD	78	93
GLENWOOD SHALE	GREEN	MEDIUM	93	98
ST. PETER SANDSTONE	WHITE	SOFT	98	130
ST. PETER SANDSTONE	WHITE	SOFT	130	184

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☐ Yes ☑ No **Above/Below** 2.25 **ft.**

Casing Diameter	Weight	Hole Diameter
18 in. to 90 ft.	70.59 lbs./ft.	18 in. to 90 ft.
12 in. to 95 ft.	29.56 lbs./ft.	18 in. to 95 ft.
6 in. to 105 ft.	18.97 lbs./ft.	12 in. to 130 ft.

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON WIREWOUND **Type**

Diameter	Slot/Gauze	Length	Set Between
3	40	85	85 ft. and 94 ft.

Static Water Level
25 ft. from Land surface Date Measured 09/10/1987

PUMPING LEVEL (below land surface)
64 ft. after 30 hrs. pumping 80 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

REMARKS
THIS WELL WAS DEEPENED & NEW SCREEN INSTALLED 0-20-1989.
ORIGINALLY SCREEN FROM 105-125 FT.

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material:	from	to 105 ft.	2 yrds.
Grout Material:	from	to 95 ft.	2.75 yrds.

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☑ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number __ HP _ Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☑ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

First Bedrock **Aquifer**
Last Strat **Depth to Bedrock** **ft.**

Well Contractor Certification

Bergerson-Caswell	27058	GLENN/TONY
License Business Name	Lic. Or Reg. No.	Name of Driller

County Well Index Online Report

434042

Printed 11/7/2012
HE-01205-07

Minnesota Unique Well No.

434045

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date
Update Date 01/14/2009
Received Date

Well Name W-420

Township	Range	Dir	Section	Subsections
117	21	W	17	

Elevation ft.
Elevation Method

Well Depth	Depth Completed	Date Well Completed
67 ft.	67 ft.	10/12/1987

Drilling Method Non-specified Rotary

Well Address

ST LOUIS PARK MN 55614

Geological Material	Color	Hardness	From	To
SAND & TOP SOIL	BLACK	SOFT	0	2
SAND, T. GRAVEL & SILT	BROWN	V.SOFT	2	5
PEAT	BLACK	V.SOFT	5	15
SILTY CLAY-ORGANIC	WHITE	SOFT	15	20
COARSE SAND & GRAVEL	BROWN	MEDIUM	20	35
COARSE GRAVEL, T. SAND	VARIED	MEDIUM	35	67

Drilling Fluid Bentonite

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Monitor well

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☐ Yes ☑ No **Above/Below** 2.5 **ft.**

Casing Diameter	Weight	Hole Diameter
6 in. to 40 ft.	18.97 lbs./ft.	12 in. to 40 ft.
12 in. to 40 ft.	49.56 lbs./ft.	12 in. to 67 ft.

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON WIREWOUND **Type**

Diameter	Slot/Gauze	Length	Set Between
6	70		40 ft. and 57 ft.
6	70		62 ft. and 67 ft.

Static Water Level
11 ft. from Land surface Date Measured 08/25/1987

PUMPING LEVEL (below land surface)
30 ft. after 72 hrs. pumping 200 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

REMARKS
WEST WELL W-420 TV BY SUMMITT ENVIRONMENTAL JUNE 2001.

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: from to 35 ft. 0.75 yrds.

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☑ No

Pump ☐ Not Installed Date Installed 10/12/1987
Manufacturer's name GRUNDFOS Model number SP6-10 HP 2 Volts 200
Length of drop Pipe 42 ft. Capacity 25 g.p.m Type Submersible Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☑ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

First Bedrock
Last Strat
Aquifer
Depth to Bedrock ft.

Well Contractor Certification

Bergerson-Caswell	27058	HOLMAN, G.
License Business Name	Lic. Or Reg. No.	Name of Driller

County Well Index Online Report

434045

Printed 11/7/2012
HE-01205-07

Minnesota Unique Well No.

434044

County Hennepin
Quad Minneapolis South
Quad ID 104A

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date
Update Date 01/14/2009
Received Date

Well Name W-421

Township	Range	Dir	Section	Subsections
117	21	W	17	

Elevation ft.
Elevation Method

Well Depth	Depth Completed	Date Well Completed
84 ft.	84 ft.	10/12/1987

Drilling Method Non-specified Rotary

Well Address

ST LOUIS PARK MN 55416

Drilling Fluid Bentonite

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Monitor well

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☐ Yes ☑ No **Above/Below** 2.5 **ft.**

Geological Material	Color	Hardness	From	To
SAND & TOP SOIL	BLACK	SOFT	0	2
SAND, T. GRAVEL & SILT	BROWN	V.SOFT	2	5
PEAT	BLACK	V.SOFT	5	15
SILTY CLAY-ORGANIC	WHITE	SOFT	15	20
COARSE SAND & GRAVEL	BROWN	MEDIUM	20	35
COARSE GRAVEL	VARIED	MEDIUM	35	67
PLATTEVILLE LIMESTONE	ORN/GRN	V.HARD	67	84

Casing Diameter	Weight	Hole Diameter
12 in. to 20 ft.	49.56 lbs./ft.	12 in. to 20 ft.
6 in. to 67 ft.	18.97 lbs./ft.	12 in. to 67 ft.

Open Hole from 67 ft. to 84 ft.

Screen NO **Make** **Type**

Diameter	Slot/Gauze	Length	Set Between

Static Water Level
11 ft. from Land surface Date Measured 08/25/1987

PUMPING LEVEL (below land surface)
40 ft. after 48 hrs. pumping 50 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

REMARKS
EAST WELL W-421 TV BY SUMMITT ENVIRONMENTAL JUNE 2001.

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: Neat Cement from to 67 ft. 1 yrds.

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☑ No

Pump ☐ Not Installed Date Installed 10/12/1987
Manufacturer's name GRUNDFOS Model number SP6-10 HP 2 Volts 200
Length of drop Pipe 42 ft. Capacity 25 g.p.m Type Submersible Material Steel (black or low carbon)

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☑ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

First Bedrock **Aquifer**
Last Strat **Depth to Bedrock** ft.

Well Contractor Certification

Bergerson-Caswell	27058	HOLMAN, G.
License Business Name	Lic. Or Reg. No.	Name of Driller

County Well Index Online Report **434044**

Printed 11/7/2012
HE-01205-07

Minnesota Unique Well No.

434043

County: Hennepin
Quad: Minneapolis South
Quad ID: 104A

Well W422

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date
Update Date 01/14/2009
Received Date

Well Name

Township	Range	Dir	Section	Subsections
117	21	W	17	

Elevation ft.
Elevation Method

Well Depth	Depth Completed	Date Well Completed
78 ft.	78 ft.	10/12/1987

Drilling Method Non-specified Rotary

Well Address
6425 OXFORD ST
ST LOUIS PARK MN 55416

Geological Material	Color	Hardness	From	To
SAND	BROWN	SOFT	0	15
CLAYEY SAND	BROWN	MEDIUM	15	25
SILTY F. SAND; T. GRAVEL	BROWN	MEDIUM	25	55
MED. GRAVEL; T. SAND	VARIED	HARD	55	78

Drilling Fluid Bentonite

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Monitor well

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☐ Yes ☑ No **Above/Below** 2.5 **ft.**

Casing Diameter	Weight	Hole Diameter
12 in. to 20 ft.	49.56 lbs./ft.	12 in. to 20 ft.
6 in. to 53 ft.	18.97 lbs./ft.	12 in. to 78 ft.

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON WIREWOUND **Type**

Diameter	Slot/Gauze	Length	Set Between
6	40	25	53 ft. and 78 ft.

Static Water Level
25 ft. from Land surface Date Measured 09/10/1987

PUMPING LEVEL (below land surface)
42 ft. after 72 hrs. pumping 90 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

NO REMARKS

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: from to 48 ft. 0.5 yrds.

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☑ No

Pump ☐ Not Installed Date Installed 10/12/1987
Manufacturer's name GRUNDFOS Model number SP16-5 HP 5 Volts 200
Length of drop Pipe 42 ft. Capacity 50 g.p.m Type Submersible Material Steel (black or low carbon)

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☑ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

Well Contractor Certification

Bergerson-Caswell	27058	
License Business Name	Lic. Or Reg. No.	Name of Driller

First Bedrock
Last Strat
Aquifer
Depth to Bedrock ft.

County Well Index Online Report

434043

Printed 11/7/2012
HE-01205-07

Minnesota Unique Well No.

463012

County Hennepin
Quad
Quad ID

Well W434

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 103I

Entry Date 05/12/1995
Update Date 03/26/2012
Received Date

Well Name JORVIG PARK

Township	Range	Dir	Section	Subsections	Elevation ft.
117	21	W	16		Elevation Method

Well Depth	Depth Completed	Date Well Completed
114 ft.	114 ft.	04/29/1991

Drilling Method --

Well Address
JORVIG PARK
MN

Drilling Fluid Bentonite

Well Hydrofractured? Yes No
From Ft. to Ft.

Use Monitor well

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☑ Yes ☐ No **Above/Below** 2.5 **ft.**

Geological Material	Color	Hardness	From	To
TOP SOIL	BLACK		0	5
CLAY	BROWN		5	15
GRAVEL	BROWN		15	38
SILT	GRAY		38	40
CLAY ROCKS	GRAY		40	45
CLAY	BROWN		45	48
MED. SAND	GRAY		48	65
SILT	GRAY		65	80
CLAY, FINE SAND	GRAY		80	95
RUBBLE	GRY/TAN		95	108
SHALE, LIMESTONE	GRAY		108	112
SHALE	LT. GRN		112	112

Casing Diameter	Weight	Hole Diameter
6 in. to 99.4 ft.	10.79 lbs./ft.	12 in. to 112 ft.

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON **Type** stainless steel

Diameter	Slot/Gauze	Length	Set Between
	15	15.3	97 ft. and 112 ft.

Static Water Level
ft. from Date Measured

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

NO REMARKS

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: Neat Cement from to 109 ft. 24

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☑ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number __ HP _ Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☑ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

Well Contractor Certification

Renner E.H. Well	71015	PRAUGHT,V.
License Business Name	Lic. Or Reg. No.	Name of Driller

First Bedrock **Aquifer**
Last Strat **Depth to Bedrock ft.**

County Well Index Online Report **463012** Printed 11/7/2012 HE-01205-07

Minnesota Unique Well No.

538134

County Hennepin
Quad Minneapolis South
Quad ID 104A

Well W439

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 08/08/1994
Update Date 08/29/2012
Received Date

Well Name GRADIENT CONTROL WELL

Township	Range	Dir	Section	Subsections
117	21	W	17	

Elevation ft.
Elevation Method

Well Depth	Depth Completed	Date Well Completed
94 ft.	94 ft.	07/14/1994

Drilling Method Cable Tool

Well Address
100 GORHAM AV
ST LOUIS PARK MN

Drilling Fluid Water

Well Hydrofractured? ☐ Yes ☐ No
From Ft. to Ft.

Use Other (specify in remarks)

Geological Material	Color	Hardness	From	To
SAND/GRAVEL	BROWN	MEDIUM	0	9
BLDS/CEMENT	BROWN	MEDIUM	9	13
GRAVEL	BROWN	MEDIUM	13	17
SAND/GRAVEL	BROWN	MEDIUM	17	48
SAND--FINE	GRAY	SOFT	48	58
SAND & GRAVEL	GRAY	MEDIUM	58	80
CLAY/SILT/GRAVEL	GRAY	MEDIUM	80	90
SAND/GRAVEL	GRAY	MEDIUM	90	94
LIMESTONE	TAN	HARD	94	94

Casing Type Steel (black or low carbon) **Joint** Welded **Drive Shoe?** ☑ Yes ☐ No **Above/Below** 0 **ft.**

Casing Diameter	Weight	Hole Diameter
6 in. to 58 ft.	lbs./ft.	7 in. to 94 ft.

Open Hole from ft. to ft.

Screen YES **Make** JOHNSON **Type** stainless steel

Diameter	Slot/Gauze	Length	Set Between
6		36	58 ft. and 94 ft.

Static Water Level
40 ft. from Land surface Date Measured 07/14/1994

PUMPING LEVEL (below land surface)
40 ft. after hrs. pumping 150 g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☑ 12 in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)

NO REMARKS

Grouting Information Well Grouted? ☑ Yes ☐ No

Grout Material: Neat Cement from 0 to 2 ft. 1 bags

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed
Manufacturer's name Model number __ HP 0_ Volts
Length of drop Pipe _ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? ☐ Yes ☐ No

Variance Was a variance granted from the MDH for this well? ☐ Yes ☐ No

First Bedrock
Last Strat

Aquifer Quat. Water Table Aquifer
Depth to Bedrock 94 **ft.**

Well Contractor Certification

Renner E.H. Well	71015	PRAUGHT, V.
License Business Name	Lic. Or Reg. No.	Name of Driller

County Well Index Online Report

538134

Printed 11/7/2012
HE-01205-07

Appendix F

Capture Zone Analyses

Appendix F. Capture Zone Analyses

Six Steps for Systematic Evaluation of Capture Zones

Step 1: Review site data, site conceptual model, and remedy objectives

Step 2: Define site-specific Target Capture Zone(s)

Step 3: Interpret water levels

- potentiometric surface maps (horizontal) and water level difference maps (vertical)
- water level pairs (gradient control points)

Step 4: Perform calculations

- estimated flow rate calculation
- capture zone width calculation (can include drawdown calculation)
- modeling (analytical or numerical) to simulate water levels, in conjunction with particle tracking and/or transport modeling

Step 5: Evaluate concentration trends

Step 6: Interpret actual capture based on Steps 1-5, compare to Target Capture Zone(s), assess uncertainties and data gaps

EPA 600/R-08/003 I January 2008 I www.epa.gov/ord

The EPA's six step method for evaluating capture zones is summarized above. These steps were performed for the capture zones presented in the 2011 Annual Monitoring Report and **Figures 13 and 14** of this cessation request. Elements of these evaluation steps are contained in Sections 1 through 3 of this report:

- Step 1, Review site data – see Section 2.
- Step 1, Site conceptual model – see Section 3.1.
- Step 1, Remedy objectives – see Section 1.2 and Table 1.
- Step 2, Target capture zone – see Section 3.3.
- Step 3, Interpret water levels – see Section 3.3.
- Step 4, Calculations and modeling – see Section 3.3.
- Step 5, Evaluate concentration trends – see Section 2.
- Step 6, Interpret capture, assess uncertainties – see Section 3.3.

The hydraulic gradient and hydraulic conductivity data used to perform the specific calculations which were used to draw the capture zones are discussed below. The pumping rates and aquifer thicknesses used to calculate the width of the capture areas were provided in the 2011 Annual Monitoring Report and are summarized in **Table C-1**.

C.1 Drift Aquifer Wells W420 and W439

Hydraulic gradient

The Drift Aquifer hydraulic gradient is shown by the head difference between upgradient and downgradient wells unaffected by pumping. According to USGS Water Supply Paper 2211 (USGS, 1983) the gradient in the Drift Aquifer was approximately 10 feet per mile or 0.002 feet per foot.

Water level measurements made during Reilly Site groundwater monitoring are consistent with the literature values for hydraulic gradient and the direction of groundwater flow to the east southeast. For example, as shown in **Table 7**, well P309 had a water level elevation of approximately 881.44 feet MSL on September 25, 2012 and well W128 had a water level of approximately 875.05 feet MSL. These wells are approximately 3000 feet apart, thus the gradient between them is slightly greater than 0.002. Other pairs of wells show hydraulic gradients that vary from 0.001 to 0.002 using the data in **Table 7**.

Hydraulic Conductivity

Values for the hydraulic conductivity in the Drift Aquifer can vary by several orders of magnitude. For example, the Metropolitan Council groundwater model (Metro Model 2) identified horizontal hydraulic conductivity for Quaternary deposits at 20 ft/day to 240 ft/day with a mean of 80 ft/day. The aquifer test conducted shortly after well W420 was drilled indicated an estimated hydraulic conductivity of approximately 233 ft/day. However, the heterogeneous nature of the glacial material is not well mapped and the three dimensional pattern of high and low conductivities is poorly known. As a result, the mean value of hydraulic conductivity was estimated to be the best approximation of natural conditions to calculate a capture zone around wells W420 and W439. Note that calculating the capture zone width using a hydraulic conductivity of 233 ft/day rather than 80 ft/day (and leaving all other parameters the same) would result in a width of 275 feet rather than the 800 feet shown in **Figure 13**.

C.2 Platteville Aquifer Well W421

Hydraulic gradient

A hydraulic gradient of 0.002 was used to calculate a Platteville Aquifer capture zone for well W421 in Table C-1, below. Water elevation measurements made in 2012 (Table 7) show approximately 10 feet of head difference between wells W22 on site, and well W121 approximately one mile downgradient.

The Platteville Aquifer is not hydraulically separated from the drift by a laterally persistent confining layer, although in some locations the basal drift contains till which can influence heads, water flow, and contaminant migration. The reversal in water level elevations at wells W9 and W18 during pumping versus non –pumping conditions at well W420 is and example of this influence. In the area being monitored, from the Reilly Site eastward and southward to Highway 100, there is little difference between the water level elevations or the hydraulic gradient in the Drift and Platteville Aquifers. This is shown below by recent water level measurements made in several pairs of wells completed in the Drift and Platteville. **Table 7** shows less than 1.0 feet of head difference between co-located pairs of Drift and Platteville Aquifer wells (e.g., W101/W117, W427/W428, W128/W121, W9/W18, and W136/W131). Of these five pairs of wells, the only upward gradient was measured at wells W9/W18. One other pair of Drift and Platteville Aquifer wells was measured – P109/W20 - and it showed over four feet of head difference between wells. This unexpected head difference is unexplained at present, but could be due to damage to the Glenwood confining layer during drilling. There has typically been over three feet of head difference at this pair of wells dating back to the start of monitoring for the CD-RAP in 1988.

Hydraulic Conductivity

The hydraulic conductivity in the Platteville Aquifer can vary even more significantly than it does in the Drift Aquifer from place to place and in different directions at any one place. For example, a recent study calculated hydraulic conductivities of six Platteville wells ranging between 300 ft/day and 47,000 ft/day ("Hydrostratigraphy of a fractured, urban aquitard", Anderson, Runkel, and Tipping of the MGS. GSA Field Guide 24, GSA Annual Meeting, October 13, 2011). Even the aquifer thickness is debatable due to the degree of hydraulic connection between the Drift and Platteville Aquifers, which would tend to increase the effective aquifer thickness, and due to the secondary porosity in the Platteville Limestone which may provide significant flow pathways through relatively small bedding plane solution features. Anderson, et al. on the GSA Field Trip noted that most of the water in area springs was contained in bedding plane channels of the Hidden Falls member of the Platteville Limestone that were measurable in inches.

The estimated capture area of well W421 is approximately 800 feet wide using a pumping rate of 31 gallons per minute, a hydraulic conductivity of 187 ft/day, a gradient of 0.002 and an aquifer thickness of 20 feet. The value for hydraulic conductivity was derived from the 1988 pump test at well W421.

C.3 St. Peter Aquifer Well W410

Hydraulic gradient

The hydraulic gradient in the St. Peter Aquifer is 10 feet per mile (0.002) according to USGS WRI Report 90-4150. Due to the large area of capture exhibited by well W410, there may be no pairs of wells currently monitored that are uninfluenced by the pumping. However, measurements made in wells prior to the start of pumping support the literature value for hydraulic gradient. The St. Peter Aquifer Remedial Investigation Plan submitted in October 1987 in accordance with Section 8.1 of the CD-RAP includes water level measurements made by MPCA on January 24, 1985 (Table 3). The head difference between wells W14 (water elevation = 878.46) and P116 (water elevation = 864.84) located approximately 7000 downgradient, was 13.62 feet. This equates to a gradient of just under 0.002.

Hydraulic Conductivity

According to the Draft Metro Model 2 Technical Report (October 2009) the horizontal hydraulic conductivity of the St. Peter Aquifer varies from a minimum of 1 foot per day to a maximum of approximately 50 feet per day, with a mean value of approximately 13 feet per day. This mean value was used in the calculation presented in **Table C-1**.

Table C-1. Capture Area Calculations

Q=kiA where A is the cross sectional area (width * thickness) of the aquifer supplying water to the well.

So, Q=kiwb, and solving for w, w=Q/kib

Well ID	Pumping Rate (Q), gpm	Q, ft^3/day	Hydraulic Conductivity (k), ft/day	Gradient (i)	Aquifer Thickness (b), ft	Capture Area Width (w), ft
W410	53	10,203	13	0.002	100	3,924
W420	40	7,701	80	0.002	60	802
W421	31	5,968	187	0.002	20	798
W439	58	11,166	80	0.002	60	1,163

Appendix G

Buried Bedrock Valley Maps

[redacted]

Map adapted from M-001 Bedrock geologic map, Minneapolis, St. Paul and vicinity,Payne, C.M., Minnesota Geological Survey, 1965.

Legend

W414

Buried Bedrock Extent - WSP2211

Reilly Site

N

W E

S

0 0.5 1 Miles

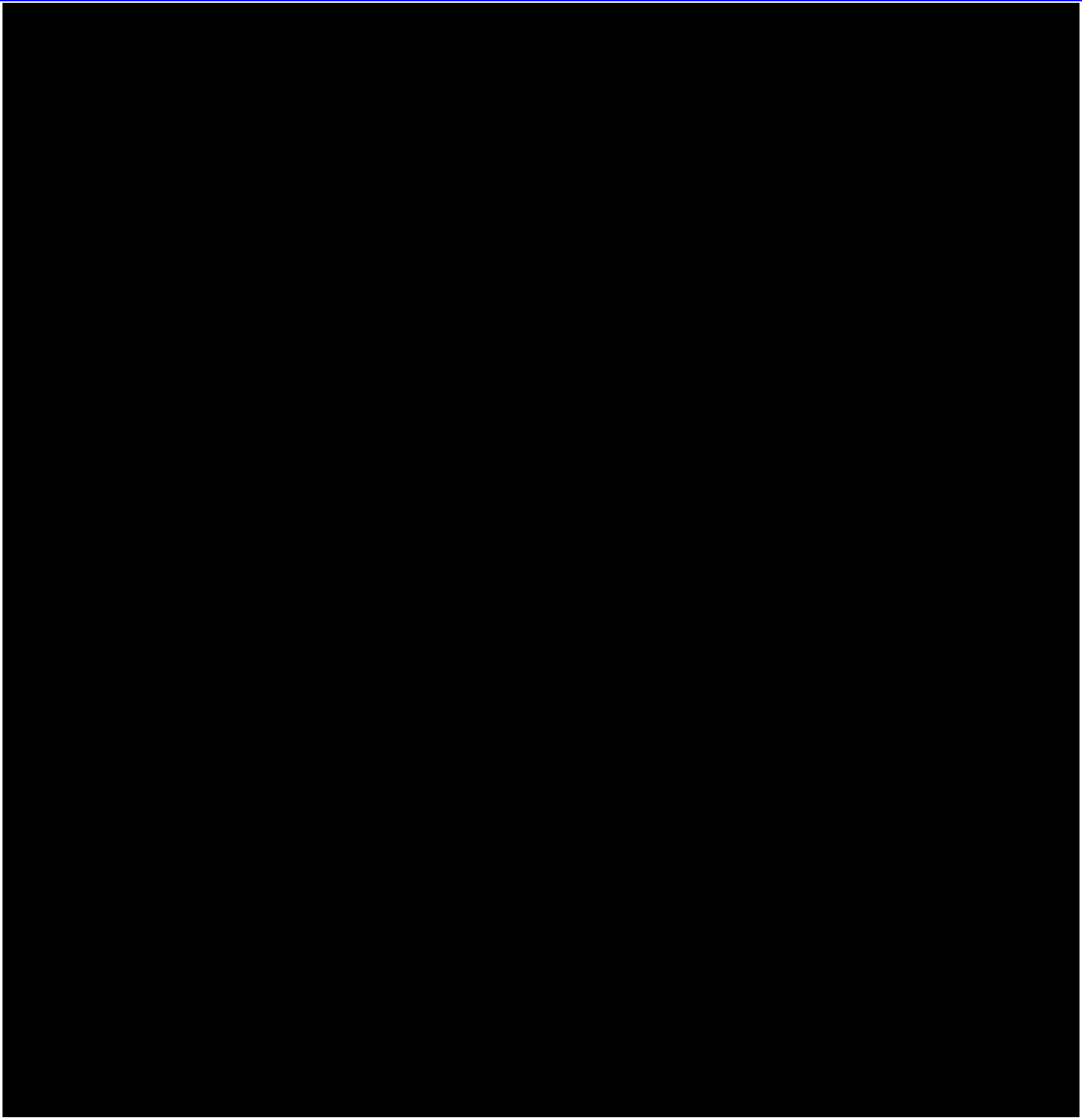
BURIED VALLEY EXTENT IN 1965

City of St. Louis Park, Minnesota

Summit Envirosolutions ®

Figure G1

File: 20121029_bv1.mxd
Summit Proj. No.: 0987-0009
Plot Date: 10-29-12
Arc Operator: JED
Reviewed by: PRB



Map adapted from M-055 Bedrock geologic and topographic maps of the seven-county Twin Cities Metropolitan Area, Minnesota,Jirsa, M.A., Olsen, B.M.,Bloomgren, B.A., Minnesota Geological Survey, 1986.

Legend

- W414
- Buried Bedrock Extent - WSP2211
- Reilly Site

0 0.5 1 Miles

N W E S

ALLEGED BURIED VALLEY EXTENT IN 1986

City of St. Louis Park, Minnesota

Summit Envirosolutions

Figure G2

File: 20121029_bv1.mxd
Summit Proj. No.: 0987-0009
Plot Date: 10-29-12
Arc Operator: JED
Reviewed by: PRB

[redacted]

Map adapted from M-104 Bedrock geology and structure of the seven-county Twin Cities Metropolitan Area, Minnesota Mossler, J.H.,Tipping, R.G, Minnesota Geological Survey, 2000.

Legend

- W414
- Buried Bedrock Extent - WSP2211
- Reilly Site

N
W E
S

0 0.5 1 Miles

ALLEGED BURIED VALLEY EXTENT IN 2000

City of St. Louis Park, Minnesota

Summit Envirosolutions ®

Figure G3

File: 20121029_bv.mxd
Summit Proj. No.: 0987-0007
Plot Date: 10-29-12
Arc Operator: JED
Reviewed by: PRB

Appendix H

Sentry Well Installation Plan

This plan describes new Drift and Platteville Aquifer monitoring wells to serve as sentry wells downgradient of wells W420 and W421. The new wells will help delineate the current extent of PAH in groundwater that exceeds MDH HRLs/HBVs and will allow an evaluation of water quality changes under non-pumping conditions in the future. The wells will be installed by a licensed water well contractor in accordance with the Minnesota Department of Health well code. In order to compare analytical results to the proposed cessation/resumption criteria, samples will be analyzed for priority pollutant PAH in accordance with the 2013 Quality Assurance Project Plan.

Well Location

Figure 15 shows the area around wells W420 and W421 including the City-owned property at the groundwater treatment facility (GTF). Existing well W33R is the proposed St. Peter Aquifer sentry well and it is located on the GTF property. The proposed location of the new Drift and Platteville Aquifer wells is adjacent to well W33R. Once the wells are installed and developed, a groundwater sample will be collected from each well and analyzed for priority pollutant PAH. The analytical results will be compared to the MDH HRLs/HBVs. If the groundwater samples are below the MDH HRLs/HBVs then that location will be appropriate for continued monitoring as sentry wells. If the groundwater samples are above the MDH HRLs/HBVs, it will be necessary to move further downgradient. **Figure 15** shows locations A, B, and C for Drift and/or Platteville Aquifer monitoring wells. It is possible that the extent of the plume is different in the two aquifers.

The City will continue to install monitoring wells down gradient as needed to find the appropriate sentry well location. Water quality analyses will confirm the status of each well drilled and indicate the need for additional wells. Locations A, B, and C shown on **Figure 15** are on City-owned property along the right of way for the Highway 7 south frontage road. The intent is to finalize the sentry well installations prior to cessation of pumping at wells W420 and W421.

Well Drilling and Construction

The wells will be drilled using a rotosonic rig with a five or ten-foot core barrel. The well completion details will mimic the wells installed by EPA for the VOC study. Well completion logs for the EPA wells are included in Appendix E. The Platteville well will be installed first and will use two-inch diameter low-carbon steel riser pipe and a 10-foot stainless steel screen in the Platteville Aquifer. Only the top ten feet of Platteville will be drilled. This amount was shown to be protective of the Glenwood confining layer during the recent geotechnical borings for the Louisiana Avenue and Highway 7 intersection project. The Platteville is approximately 17 feet thick in this area according to the logs for W33R and W421. The total Platteville Aquifer well depth is expected to be approximately 85 feet deep.

The Drift Aquifer monitoring well will be installed adjacent to the Platteville well and will be completed with two-inch diameter low-carbon steel riser pipe and a 10-foot long, 10-slot stainless steel screen installed in the sand and gravel of the middle drift as defined by USGS Water Supply Paper 2211. The total Drift Aquifer well depth is expected to be approximately 35 feet deep. Other design details for both new wells, as noted on the EPA well logs, include silica sand filter pack around the screens, neat cement and bentonite grout annual seal, concrete surface seal, and protective casing with lock.